VOLUME LIV NUMBER 2 WHOLE 472

SCHOOL SCIENCE AND MATHEMATICS

FEBRUARY 1954

School Science and Mathematics

A Journal for All Science and Mathematics Teachers

All matter for publication, including books for review, should be addressed to the editor. Payments and all matter relating to subscriptions, change of address, etc. should be sent to the business manager.

Entered as second class matter December 8, 1932, at Menasha, Wisconsin, under the Act of March 3, 1879. Published Monthly except July, August and September at 450 Ahnaip St., Menasha, Wis. PRICE. Four dollars and fifty cents a year; foreign countries $5.00; current single copies 75 cents.

Contents of previous issues may be found in the Educational Index to Periodicals.

Copyright 1954, by the Central Association of Science and Mathematics Teachers, Inc.
Printed in the United States of America

GLEN W. WARNER
Editor
Lakeville, Indiana

RAY C. SOLIDAY
Business Manager
Box 408, Oak Park, Ill.

DEPARTMENTAL EDITORS

BIOLOGY—John E. Potzger
Butler University, Indianapolis, Ind.
Joseph P. McMenamin
Oak Park-River Forest High School, Oak Park, Ill.
Nelson L. Lowry
Arlington Heights High School, Arlington Heights, Ill.

CHEMISTRY—Gerald Osborn
Western Michigan College of Education, Kalamazoo, Mich.
Allen F. Meyer
Mackenzie High School, Detroit, Mich.

ELEMENTARY SCIENCE—Milton O. Pella
The University of Wisconsin, Madison, Wis.

GENERAL SCIENCE—John D. Woolever
Mumford High School, Detroit, Mich.

GEOGRAPHY—Villa B. Smith
John Jay High School, Cleveland, Ohio

MATHEMATICS—Cecil B. Read
University of Wichita, Wichita, Kan.
George E. Hawkins
Lyons Twp. High School and Junior College, La Grange, Ill.

MATHEMATICS PROBLEMS—G. H. Jamison
State Teachers College, Kirksville, Mo.

NATURE STUDY—E. Laurence Palmer
Cornell University, Ithaca, N.Y. and The American Nature Association.

PHYSICS—Julius Sumner Miller
West Los Angeles 25, Cal.
E. Wayne Gross
R.R. 6, Bloomington, Ind.

You are invited to use the Turtox Research Service

• The Turtox Research Service is our attempt to secure for teachers and research workers in the biological sciences materials and specimens needed for their work which cannot be easily obtained from routine sources. This service costs you nothing, and we do not offer anything for sale in this connection.

There are three possible procedures: (1) If our files list sources for the special material you want, we will send you the information and you can buy direct from the source. (2) If the material you wish can best be secured by our purchasing department, we will buy it for you and bill it to you at actual cost—exactly what we have to pay for it. (3) If the wanted materials are not easily located, or if you wish specimens from many areas, you may prepare a "research request" for publication in Turtox News. This will be printed without cost to you.

If we can be of help to you, feel perfectly free to make use of the Turtox Research Service.

GENERAL BIOLOGICAL SUPPLY HOUSE
Incorporated
761-763 EAST SIXTY-NINTH PLACE
CHICAGO 37, ILLINOIS
The Sign of the Turtox Pledges Absolute Satisfaction

Poor old February has received rough treatment in the past: once the last month of the year; once composed of twenty-nine days in common years and thirty in leap years. Then Octavius Augustus stole one to make his month equal to the month of his uncle, Julius. But through all the variations of position and length February is still the greatest of the twelve in some respects—the birth-month of statesmen, scientists, and poets:

George Washington	*Galileo Galilei*	*Henry Wadsworth Longfellow*
Abraham Lincoln	*Henreich R. Hertz*	*James Russell Lowell*

CONTENTS FOR FEBRUARY, 1954

Synthetic Detergents—*Lillian Hoagland Meyer* 83

The Educational Concepts of Secondary School Science Teachers—*Paul DeH. Hurd* 89

Changes in Lay Science Articles—*Catharine Bergen* 97

The Impact of Industry on Science—*Dr. Gustav Egloff* 101

Some Practices Used in Counseling Students Prior to Enrollment in Elementary Algebra and Plane Geometry—*David J. Blick and Shirley E. Braman* 107

The AAAS Cooperative Committee on the Teaching of Science & Mathematics—*Bernard B. Watson and Donald W. Lentz* 116

Final Report to the Central Association of Science and Mathematics Teachers of Its Committee on the Significance of Mathematics and Science in Education—*George Greisen Mallinson, Chairman and Others* .. 119

A Science Annual for High School Students—*Louis Panush* 144

The Use of Large Scale Calculators—*Fred Gruenberger* 147

Central Association of Science and Mathematics Teachers. A Report of the November 26–28, 1953, Chicago Convention—*W. H. Edwards, Secretary* 150

Instructional Materials for Nature Study—*Sam S. Blanc* 152

A New Instalment Buying Interest Formula—*Lee Emerson Boyer* 155

Problem Department—*G. H. Jamison* 156

Books and Pamphlets Received 163

Book Reviews 164

School Science and Mathematics

We Cover the Earth

Is read by subscribers in every state of the Union, all provinces of Canada, and thirty-three foreign countries.
It is owned by teachers, managed by teachers, and edited by teachers.
It comes to your desk every school month.

Interesting Articles in Volume 53

Science and School Camping—Human Conservation—Wonderland of Geology—Mass Education—The Trisection of the Area of a Circle—Conservation Across the United States—New Developments in Atomic Energy—Elementary Science Teaching Hints—The Place of Mathematics in Secondary Education—The Science Janus—Seashore Shell Life of the Northwest—Artificial Magnets—Arithmetic for Arithmetic Teachers—How to Use the Textbook in Science Teaching—How Important Is Animal Experimentation to My Health?—The Field Tour Method of Teaching Biology—Oyster Lore.

Helpful Reprints and Supplements

Atomic Energy: A Science Assembly Lecture, illustrated	.25
Mock Trial of B versus A—A play for the Mathematics Club	.30
100 Topics in Mathematics—for Programs or Recreation	.25
Poison War Gases	.20
New Emphases in Mathematical Education, with bibliographies	.25
Popular Mathematics: Bibliography	.20
Mathematics Problems From Atomic Science	.25
The Mathematics of Gambling	.25
Computations With Approximate Numbers	.25
The Radical Dream—A Mathematical Play for Puppets	.20
Geometry Theorems: A List of Fundamentals	.20
How Water Serves Man. A teaching unit	.20
Biology Reading List	.20
Won by a Nose. A chemistry play	.25
Radioactive Isotopes: A Science Assembly Lecture, illustrated	.25
Kem: Two Games for Chemistry Classes	.15
Modern Periodic Arrangements of the Elements; illustrated	.25
Ion Visits the Realm of Air. A Play	.25
The King of Plants. A play for science clubs	.25
Three Families of Great Scientists: dramatized	.30
Some Lessons About Bees. A 32-page booklet; illustrated	.20
The Triumph of Science. A play for auditorium programs	.25
In a Sound Studio. A play: Physics and Music	.25
In Quest of Truth. A play in two parts	.25
A Student's Approach to Mechanics	.25
Youth Looks at Cancer. A biology play	.25
Apparatus for Demonstrating the Fundamentals of Radio	.20
Youth Opens the Door to Cancer Control, bibliographies, 1949	.25
Science in the Grades: Practical Contributions—35 pp.	.30
Extracting Aluminum. A one act chemistry play	.15
Vitalizing Chemistry Teaching. A Unit on the Halogens	.15
Telescope Making Illustrated	.25
A Scientific Assembly Program, Wonders of Science	.30
What Is Scientific Method?	.20
Elementary School Science Library	.20
Projection Demonstrations in General Science	.20
Atomic Energy—A Play in Three Scenes	.30
Motion Pictures for Elementary Science	.25

Orders for Reprints must be prepaid.

SCHOOL SCIENCE AND MATHEMATICS

Price $4.50—Foreign $5.00

No numbers published for July, August and September

P.O. Box 408 **Oak Park, Ill.**

SCHOOL SCIENCE
AND
MATHEMATICS

VOL. LIV FEBRUARY, 1954 WHOLE NO. 472

SYNTHETIC DETERGENTS

LILLIAN HOAGLAND MEYER
Western Michigan College of Education, Kalamazoo, Michigan

For centuries man has kept his clothing, his dishes, and his home clean with the aid of soaps. But in the nineteen thirties, two new products closely related to the soaps, sodium alkyl sulfates, and the sodium acyl glyceryl sulfates, were introduced. These products had one marked advantage over soaps—they do not form a precipitate in hard water. The volume of sale was very small and no effect could be seen on soap production. However, during the war, with the soap shortage many consumers tried synthetic detergents. Then during the third quarter of 1947, a number of new synthetic detergents began to reach the market and even in soft water areas, they began to gain in popularity. Now, six years later, the value of synthetic detergents sold in household packages is half that of soap and the total production of soap and soap products has shown a marked downward trend. Thus in a short time in the United States the ancient household cleaner, soap, has been partially displaced by the new agents.

The term "detergent" means any cleaning agent whether the cleaning problem is one facing a fabricator of steel or a young mother. We shall restrict its meaning for this article to a household cleaning agent, and by doing this, restrict our field considerably. Soap is, of course, a detergent and since it is produced by a chemical reaction, it is in the strictest sense of the word a synthetic detergent. However, the term "synthetic detergent" is generally applied to substances other than soap which have detergent properties and which are synthesized by a series of chemical reactions.

The composition of the soil which must be removed from a surface during cleaning varies considerably. Clothing is soiled by contact

with our bodies and absorption or adsorption of water soluble substances in sweat and the greasy sebum secreted by sebaceous glands. The grease holds particles of soot and dust onto the fibers. Clothing may be soiled with a great variety of other mixtures—anything from road tar to gravy. The water soluble substances can be readily removed, but the big problem in cleaning clothes is the removal of greasy compounds and with them particles of dust and soot. In cleaning dishes it is the greasy deposits and the material which sticks to the dishes imbedded in grease which is difficult to remove. On walls and floors the soil which is hard to clean off is also insoluble in water—food fats and their break down products, fuel oil and its fragments, and greases and oils from coal.

A good detergent is one which will readily lift the soil from the surface without injuring the surface and keep the soil suspended in the wash water until it can be rinsed away. If the soil is redeposited, the surface will become streaked and grey. How can this be accomplished?

It is believed that in order for a compound to act as a detergent, it is necessary to have a polar portion of the molecule which will have an attraction for water, and a non-polar portion which will have no attraction for water, but one for greases. Then one part of the molecule, the non-polar part, will dissolve in the small globules of grease as they are lifted from the surface while the other end of the molecule will dissolve in water. The tiny globule will be surrounded soon by detergent molecules, each with one end in the globule and the other in the water. Such a detergent coat will prevent the globules from coalescing and precipitating again on the surface. A molecule which is polar at one end and non-polar at the other also aids in lifting the grease from the surface. All good detergents are also good wetting agents. They decrease the surface tension of water markedly and allow the wash solution to penetrate fibers and to creep under layers of grease. Washing cannot be brought about by soaking however. No detergent is efficient enough to lift the grease from the surface through its own activity, to form globules surrounded by detergent, and to keep them suspended. All detergents need some mechanical action in order to accomplish the cleaning. Rubbing, churning, and squeezing are operations which force wash water and detergent around and between soil.

The household detergents available on the grocery shelves today are either anionic or nonionic detergents. An anionic detergent is one which possesses a small positive ion such as sodium and a long organic negative ion. The nonionic detergents do not form ions but they do possess at one end of the molecule, groups such as ether oxygens which have an attraction for water. The rest of the molecule is hydro-

carbon and, of course, possesses no attraction for water. It is nonpolar. Soaps are anionic detergents.

Anionic (R^-Na^+)

alkyl sulfates $C_{12}H_{25}OSO_3^-Na^+$
(alcohol sulfates)

Alkyl aryl sulfonates $C_{12}H_{25}$

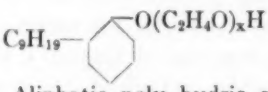
$SO_3^-Na^+$

Acyl glyceryl sulfates

$C_{12}H_{25}COOCH_2$
$HOCH$
$HCOSO_3^-Na^+$
H

Nonionic

Alkyl phenyl polyglycol ether
(alkyl phenol ethyoxy ethers)



Aliphatic poly hydric alcohol esters and ethers

$C_{12}H_{25}COO(C_2H_4O)_xH$

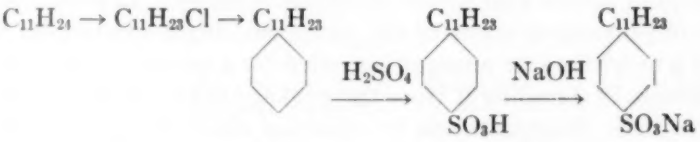
Fatty acid amides

$C_{12}H_{25}CONHC_2H_4OH$

The alcohol sulfates were first prepared by the catalytic reduction of fatty acids, followed by treatment with sulfuric acid, and neutralization with sodium hydroxide. In 1933 reduction with sodium and an alcohol was developed and has been widely used since.

$$C_{11}H_{23}COOH \xrightarrow{\text{red.}} C_{11}H_{23}CH_2OH \xrightarrow{H_2SO_4} C_{12}H_{25}OSO_3H \xrightarrow{NaOH} C_{12}H_{25}OSO_3Na$$

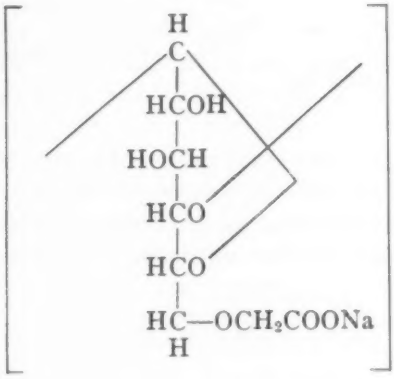
The alkyl aryl sulfonates were first made from the kerosene fraction of petroleum and benzene. The alkyl group varies from eleven to fourteen carbons and is attached to the aryl group by a Friedel-Crafts reaction. Propylene tetramer obtained from petroleum cracking, is now widely used in place of kerosene. Benzene is the most common supplier of the aryl group although toluene and naphthalene are also used. The resulting hydrocarbon is then sulfonated with sulfuric acid and neutralized with sodium hydroxide.



The properties of the final product are influenced by both the nature of the alkyl and the aryl group. All alkyl aryl sulfonates are, therefore, not identical in their properties.

Compounds which increase the detergency of soaps have been

known for many years. They are called builders and have been packaged with soap in washing compounds both for the home and for commercial launderies and restaurants for many years. When synthetic detergents were first developed they could not compete with soap in soft water as a cleaning agent, but with the development of builders for the detergents, some are now as efficient in cleaning heavily soiled cotton as soap in soft water. Sodium carboxy methyl cellulose (carbose) acts as a builder for some of the anionic detergents as well as some of the nonionic detergents. It is cellulose with a carboxy methyl group probably attached to the primary alcohol group of each glucose residue:



The polyphosphates are also excellent builders. The production of these interesting compounds has increased a great deal during the last five years and most of it goes into detergents. In 1951, it was estimated that 90% of the tripolyphosphate ($Na_5P_3O_{10}$) and 85% of the tetra sodium pyrophosphate ($Na_4P_2O_7$) produced was used to build detergents. Sodium silicates which are effective builders for soaps are also used occasionally with synthetic detergents. Sodium sulfate enhances the effectivness of synthetic detergents and it appears in most products on the retail market. It is formed in the neutralization of the sulfates or sulfonates and is not removed.

Sodium sulfate also serves to cut the detergent, an important function in preventing waste of the detergent. If pure detergent is packaged a much smaller amount is needed for a specific cleaning job. The housewife in dumping it from the package may use too much.

Synthetic detergents can be classified either as light weight (light duty) or heavy weight (heavy duty) detergents. Light weight detergents will do a satisfactory cleaning job on lightly soiled surfaces and they all have a pH close to 7. Heavy weight detergents are designed to effectively clean heavily soiled cottons or other heavily soiled surfaces. Their pH is considerably above 7. This high pH is the result

of the alkaline builders, the phosphates and silicates which on hydrolysis increase the hydroxide ion concentration of the wash solution.

When we choose a detergent for a particular task, the pH is a factor to consider along with its effectiveness as a detergent. Proteins are sensitive to high pH and protein fibers such as wool and silk show rapid deterioration if they are exposed to solutions of high pH repeatedly or for extended periods. The fibers become hard and brittle and the wool fibers show an increased tendency to shrink and to felt.

Commercial Name	Type	Detergent	Builder	pH of 0.5% Solution
		Heavy Weight Detergents		
Tide	Anionic	Sodium alkyl sulfate $ROSO_3Na$	10% Na_2SO_4 Polyphosphate	9.8– 9.9
Fab	Anionic	Sodium alkyl aryl sulfonate $RC_6H_4SO_3Na$	30% $NaSO_4$+ builder	9.4– 9.6
Surf	Anionic	Sodium alkyl aryl sulfonate $RC_6H_4SO_3Na$	1% Na_2SO_4	8.5– 9.0
Cheer	Anionic	Sodium alkyl aryl sulfonate $RC_6H_4SO_3Na$	16% Na_2SO_4 polyphosphate	9.9
Detergent Oxydal	Anionic	Sodium alkyl sulfate and Sodium alkyl aryl sulfonate	Na_2SO_4+ silicates+ polyphosphates	10.0–10.2
American Family Detergent	Anionic	Sodium alkyl sulfate and Sodium alkyl aryl sulfonate	Na_2SO_4+ silicates+ polyphosphates	10.0–10.2
		Light Weight Detergents		
Dreft	Anionic	Sodium alkyl sulfate $ROSO_3Na$		7.2– 7.3
Vel	Anionic	Sodium acyl glyceryl sulfate $ROCH_2CHOHCH_2OSO_3Na$		6.9– 7.2
All	Nonionic	Polyethoxy esters of fatty acids $RCOO(C_2H_4O)_xH$	Phosphate	7.0– 8.0
Breeze	Anionic	Sodium sulfonate amide of fatty acids $RCOONHSO_3Na$	60% Na_2SO_4	7.0– 7.5
Trend	Anionic	Sodium alkyl aryl sulfonate $RC_6H_4SO_3Na$	70% Na_2SO_4	7.0– 8.0

The proteins of the skin probably show similar reactions. If the skin of the hands is in contact with solutions of high pH for any length of time the skin swells and reddens. When they are removed from the solution, the swelling soon subsides but the redness is followed by chapping and roughness. Synthetic fibers, even nylon which has marked chemical similarity to proteins, do not appear to suffer from washing in heavy duty detergents. However since they are seldom heavily soiled, a light weight detergent is the one of choice.

But which detergents on the grocer's shelf are light weight and which heavy weight? The advertizing claims are frequently so extravagent that even the most gullible consumer must have a few moments of doubt. However, they can be roughly classified by the placement of emphasis on the front of the box. Those detergents which emphasize cleaning of fine fabrics and dishwashing are light weight or light duty detergents. Those which emphasize family laundry are heavy weight or heavy duty detergents.

Synthetic detergents find many other applications in household cleaning agents. Scouring powders are composed of finely abrasive material such as silicon dioxide, but most contain a detergent as well. The detergent increases the effectiveness of the scouring powder by acting as a wetting agent and often as a foaming agent. Synthetic detergents are finding wide use in scouring powders today.

In shampoos, synthetic detergents sometimes present a problem because they are too effective. The oil and greases which render the hair manageable are thoroughly removed during shampooing, leaving it dry and fluffy. Manufacturers often add other ingredients which diminish the detergency of the product or even add oils to decrease the cleaning properties and leave the hair soft and pliable.

Selected Bibliography

1. Snell, F. D., "Synthetic Detergents," *Chem. Eng. News*, **30,** 30–31 (1952).
2. Neidig, C. P. and Hershberger, A. B., "Organic Synthetics," *Chem. Eng. News*, **30,** 3610–15 (1952).
3. Rainey, J. L. and Denoon, C. E., Jr., "Nonionic Surface Active Agents," *Chem. Eng. News.*, **31,** 4521–23 (1953).
4. Snell, C. T., "Synthetic Detergents and Surface Active Agents," *J. Chem. Ed.*, **24,** 505–11 (1947).
5. Kushner, L. M. and Hoffman, J. I., "Synthetic Detergents," *Sci. Am.*, **185,** 26–30 (1951).

Sealer finish for knotty pine and other natural woods used in the home consists of synthetic plasticized resins mixed with a quick-drying gum base. Sprayed or brushed directly on the wood, the finish maintains surface protection for at least five years, the manufacturer reports.

THE EDUCATIONAL CONCEPTS OF SECONDARY SCHOOL SCIENCE TEACHERS

PAUL DEH. HURD
Stanford University, Stanford, Calif.

Secondary school science teachers have published thousands of articles on the teaching of science during the past half-century. In each article are expressed the ideas or experiences which some teacher believes are of significance both to himself and to other science teachers. A critical examination of these writings should reveal many ideas and problems relative to the teaching of secondary science. The accumulated opinions of hundreds of science teachers over a period of years, while lacking the vigor and refinement of formal educational research, are not without value in a determination of the more persistent problems of science teaching.

To obtain a sampling of the educational thinking of science teachers on the various aspects of science teaching an analysis was made of 1,373 *opinionated* articles which had been published in SCHOOL SCIENCE AND MATHEMATICS, and *Science Education*. The articles used in the study were selected from the alternate volumes of SCHOOL SCIENCE AND MATHEMATICS starting with the year 1901 and continuing through 1951; and similarly with *Science Education* starting with the year 1931.

As the survey was to be confined to the *educational opinions* of science teachers the following criteria were established for the selection of articles to be analyzed.

(1) The article was an expression of opinion and not the result of formal research.
(2) The article was upon some phase of science teaching related to the secondary school or grades 9, 10, 11, or 12.
(3) The article had only one author as contrasted to a committee report.
(4) The article was concerned with science education upon a professional basis and not with some phase of scientific achievement unless a direct reference was made to its implications for science teaching.

For any given year a number of articles on science teaching were reviewed but not included in the study, as they failed to meet the educational requirements of the criteria. The majority of the rejected articles were concerned with techniques developed by teachers to demonstrate a fact, principle, or process. For example, an article on a different method for demonstrating osmosis would *not* be included

in the tabulations if the article consisted of nothing more than a description of procedure. If, however, the writer stated the technique was developed with a specific educational purpose in mind, such as, "to help students develop a better understanding of a controlled experiment," then the article would be included in the tabulations.

Each article selected for study was abstracted in terms of its educational points of view for teaching science. The ideas expressed were recorded as a series of statements and then classified under one of the following aspects of science education:

a. Concepts of learning
b. Aims or objectives
c. Criteria for the selection of subject matter
d. Methods for the organization of content
e. Classroom procedures
f. Laboratory procedures
g. Testing or evaluation procedures
h. Appeals for new courses or changed emphasis in the science curriculum
i. References to the qualifications of science teachers

The number of articles satisfying the criteria in the fifty-one year period was 1,373. From these articles a total of 3,133 educational ideas or concepts on the teaching of secondary school science were abstracted. In Table I, is shown the distribution of the articles and statements of ideas for the period of the study.

The total number of statements organized under the various categories of science teaching as well as by the period of time in which the statements were made is shown in Table II. It will be noted that the comparative emphasis upon the different aspects of science teaching is neither uniform nor constant. The data in Table II show that teachers have always been more concerned with objectives than with any other aspect of science teaching. Also, that educational psy-

TABLE I. DISTRIBUTION OF ARTICLES AND STATEMENTS ON SCIENCE TEACHING FROM 1901 TO 1952

Period	Dates of Each Period	Number of Articles	Number of Statements
I	1901–1910	203	683
II	1911–1920	195	534
III	1921–1930	247	619
IV	1931–1940	342	578
V	1941–1951	386	719
	Totals	1,373	3,133

TABLE II. DISTRIBUTION OF 3,133 STATEMENTS ON SCIENCE TEACHING BY PERIODS FROM 1901 TO 1952

Aspect of Science Teaching	Periods					Totals
	1901–1910	1911–1920	1921–1930	1931–1940	1941–1951	
Psychology of learning	22	53	37	14	58	184
Objectives of science teaching	233	119	162	139	138	291
Criteria for the selection of content	122	118	98	102	127	567
Organization of content	38	66	88	109	69	370
Classroom procedures	61	38	55	68	103	325
Laboratory procedures	121	55	60	50	46	332
Testing and evaluation	9	13	63	27	29	141
Comments on particular courses or areas of knowledge regarding their inclusion in the curriculum	39	56	27	18	64	204
Comments upon teacher education and qualifications	38	16	29	51	85	219
Totals	683	534	619	578	719	3,133

chology as it is applied to the teaching of science is seldom a topic upon which science teachers write.

In the following paragraphs a summary of the major opinions or ideas of science teachers related to the different aspects of science teaching is presented. In every instance the statements listed represent 75% or more of the total number of ideas mentioned in each category.

PSYCHOLOGY OF LEARNING

Of the 3,133 statements analyzed only 184 were concerned with an application of some principle of educational psychology to science teaching. One-hundred and sixty-two of these statements can be accounted for as follows:

1. Science courses should provide for individual differences.
2. Students learn more effectively when the work is interesting to them.
3. Students must be given direct practice in the use of the principles and methods of science if significant results are to be obtained in the development of problem-solving skills.

The last statement did not appear in the literature until after 1930 but since then has been mentioned with increasing frequency. "Individual differences" to the majority of writers was interpreted almost wholly as a difference in intellectual ability.

The statements which indicated an application of psychological concepts to science teaching were both small in number and limited

in range. The data suggest that some of the difficulties encountered in the teaching of science may be partially due to a failure to apply the results of pertinent psychological principles to teaching.

Objectives of Science Teaching

Science teachers are primarily interested in the purposes for which science should be taught in the secondary school. Articles about objectives accounted for the largest number of statements in every period covered by the study, a total of 791 comments. The major objectives of science teaching supported by teachers throughout the fifty-year period were:

(1) To train students in the scientific method of thinking (191)*
(2) To develop certain scientific attitudes within students (105)
(3) To acquire a fund of useful information (60)
(4) To develop an understanding of the major principles of science (59)

The last two aims of science teaching have lost considerable status in the last twenty years. The articles written since 1930 rank scientific thinking first, scientific attitudes second, and then give prominence to the following objectives in the order mentioned:

To appreciate the contribution of science to society (42)
To aid the student to discover a vocational interest (21)

From the negative point of view teachers feel that the purposes of science teaching are not being achieved and are in serious need of re-evaluation.

A total of twenty-six major aims for the teaching of secondary school science were identified in the 1,373 articles abstracted. Many of these objectives reflected a current educational movement and died with the movement. In some instances statements on the purposes of science teaching seem to lose status at one period and to regain it years later. In the decade from 1901–10 general education objectives were prominent in the thinking of science teachers. Then for a period of thirty years little attention was directed in this direction. Recently, 1940 to 1952, an interpretation of the objectives of science courses in terms of general education has been the leading subject for teachers writing on science education.

Criteria for the Selection of Science Content

The question of what to teach has always been an important question in the minds of science teachers. Criteria for the selection of sub-

* Numbers indicate the frequency with which each statement was mentioned in the period from 1901 to 1952

ject matter were discussed 567 times and ranked second in frequency of discussion by science teachers.

There is general agreement that the curriculum for secondary school science courses, in order of frequency of mention, should (1) be related to the interests of the majority of students, (2) be practical, (3) be related to everyday living, (4) have reference to the local community, and (5) have wide social and economic significance. These five criteria account for eighty per cent of all the comments made on the selection of subject matter for secondary school science courses. The selection of experiences in terms of their social and economic significance has had more emphasis since 1940 than any other criteria. The use of college entrance requirements and the use of a single textbook as a basis for the selection of course contents are consistently rejected by science teachers as worthy criteria, as shown by their published opinions.

Organization of Content

Those who write on the teaching of science have favored the organization of courses around "projects" over all other methods. Since 1940, however, there has been a decreasing number of articles in support of this method. "Principles of science" around which learning activities may be related ranks second, in frequency of mention, as a method of organization. Science textbooks, while severely criticized by teachers, nevertheless rank third as a recommended guide for the planning of course experiences.

Organization of the science curriculum in terms of "problems," though fourth in frequency of mention, has been in and out of favor more than any other method. For the first forty years of this study there seemed to be no definite agreement as to what should be the nature of the "problems." Since 1940 there is a consensus that "current problems of the greatest social significance," which also provide for an integration of science and non-science subject matter, should be the organizational basis for science courses.

Classroom Procedures

Classroom procedures have been defined, for the purposes of this study, as the specific techniques of instruction and the instructional aids used to facilitate learning on the part of the student.

Classroom teaching procedures or techniques most often written about by science teachers over the past half-century were concerned with: (1) a wider use of visual aids, (2) more field trips or excursions, (3) extensive course references, (4) more teaching methods which resemble the scientific method, (5) extension of the socialized recitation. The value of visual aids and field trips as instructional techniques

accounts for almost half of the comments on effective teaching procedures for the past fifty years. Science teachers also write enthusiastically in support of science clubs particularly as they serve to stimulate an interest in science courses and provide an opportunity for the integration of science knowledge. However, as judged by the literature, teacher interest in science clubs seems to have dropped during the last ten years.

Science teachers consistently express a disappointment concerning available research on the effectiveness of the different teaching methods commonly used in secondary school science courses.

Laboratory Procedures

Comments about laboratory procedures accounted for 332 of the 3,133 statements recorded. This figure, however, should not be interpreted to mean the extent to which science teachers have written about science laboratory work. In terms of the criteria used for the selection of articles only those mentioning some educational implication of laboratory procedures were tabulated. The data thus indicate only the educational values or purposes of laboratory activities.

Consistently throughout the fifty-year period of the study science teachers have rated *individual* student laboratory experiments as the prime essential for a good science course. The importance of having students maintain a science notebook rated second, in terms of the total number of comments; however, after 1930 discussions upon this topic dropped practically to zero.

The comments on laboratory teaching within the *last* decade, as revealed by periodical literature, may be summarized as follows: (1) extensive use of individual laboratory experiments should be continued; (2) demonstration experiments should be widely used in conjunction with class discussions; (3) more experiments should be of a practical nature; (4) an effort should be made to increase the number of controlled experiments, and (5) students should have some opportunity to develop their own experiments. From the negative standpoint teachers feel that laboratory experiments, as typically carried out, have failed to make students more observant or skillful in reasoning. Many teachers are of the opinion that better learning could be achieved if science laboratories were more adequately equipped. It was evident from the 332 comments on science laboratory work that there is a greater concern about the "how" of laboratory work than the "why" of laboratory work.

Testing and Evaluation

Testing and evaluation as an aspect of science teaching is seldom

commented upon by those writing for science education magazines. Only 141 statements or 4.5% of the 3,133 statements tabulated were upon some phase of testing and evaluation. The period of greatest interest in testing is to be found in the interval from 1921–1930 when nearly half of the total number of comments on testing for the past fifty years were recorded.

Science teachers expressed the following ideas on testing and evaluation (in order of decreasing frequency):

1. More objective tests should be used in science teaching.
2. Standardized tests have many values for science teaching, particularly for diagnostic purposes.
3. All the objectives of science teaching should be evaluated.
4. Science examinations should contain questions which require students to apply principles of science to life situations.
5. Test results should function in the guidance of students.

Any recent trends in evaluation, as revealed within the limitation of this study, would be that all the objectives of science should be tested and that specific provisions should be made for testing the students' application of knowledge to life situations. Nearly all the comments on grading were concerned with objectivity and with the percent of the final grade which should be based upon laboratory work.

New Courses or Topics

Articles in which there was an appeal for greater emphasis upon a science topic or an appeal for a new type of science course contributed 219 of the 3,133 tabulated statements. The largest numbers of articles written in favor of including a new course in the secondary curriculum was for general science. The peak period for these articles was between 1911–1920. Biology as a secondary school subject was introduced into the curriculum with comparatively few articles written for or against it.

Since 1941 the articles written supporting topics or courses to be added to or more strongly emphasized within the science curriculum have ranked as follows: (1) conservation; (2) health and hygiene; (3) a physical science course; (4) safety; (5) ecology; and (6) sex education. Half of the 219 statements in this category have emphasized the need for a greater stress on conservation and health education. The number of articles in which a need was expressed for a physical science course in the high school is increasing rapidly. If only the period for the last five years was considered, the number of articles appealing for a physical science course would outrank all others.

Teacher Education and Qualifications

Science teachers frequently express their opinion about their own scientific and educational background. In every decade since 1900 science teachers have expressed their outstanding professional need to be "a broader background of scientific knowledge." Of the 219 comments on teacher qualifications 91 dealt with their scientific background. In seventy-four instances teachers felt they were "poorly trained in the methods and techniques of teaching science." Nearly two-thirds of the latter remarks were made since 1930.

Other problems faced by science teachers, the majority of which have appeared in the literature since 1940, are: (1) a need for a wider background in educational psychology; (2) more training in the social sciences; (3) some way of keeping up to date both with professional and with scientific achievements. It was apparent from the statements recorded that science teachers are finding some difficulty putting into practice many of the modern concepts of science education proposed over the last twenty years. Repeatedly science teachers express a desire for the type of training recommended in the yearbooks on science teaching.

Conclusions

Within the limitations of the type of data used in this study on the educational reflections of science teachers, specific conclusions are not indicated beyond those listed in each section of the report. An examination of the data as a whole does seem to imply, however, certain broad generalizations in regard to science education. It is apparent at the onset that there is no consistent educational theory which will bring the conclusions in each section of the report to a focus. There is a greater emphasis upon "science objectives" and "how to teach," than upon any fundamental educational principles around which to build a system of teaching practices. While it is generally recognized that effective teaching rests heavily upon the utilization of the basic principles of educational psychology to direct student learning, these principles and suggestions for their application to science teaching are seldom described in the literature in science education. References to students as individuals, what happens to students in a learning situation, and how these results may be evaluated, are also infrequently mentioned. In recent years teachers have become more aware of the impact of science upon society and of the need to provide students with a different type of science education for modern living.

CHANGES IN LAY SCIENCE ARTICLES

CATHARINE BERGEN
State Teachers College, Jersey City, New Jersey

In an earlier article the author reported on a study of science articles written for laymen.* It was indicated at that time that the number of science articles in *Harper's Magazine* seemed to have been increasing since 1930 and that a science background on the part of the reader was assumed in some of the later but not in the earlier articles. A more extended study of both of these observations has been made utilizing *Harper's Magazine* for every fifth year (with two exceptions) back to 1860.

CYCLES IN *Harper's* SCIENCE

It was originally planned to analyze the science articles in every decade year of *Harper's*. As it was founded in the middle of the year 1850, 1860 was taken as the first complete decade year. From this part of the study it appeared that there had not been a steady increase in science articles since 1860 but that the numbers of such articles varied in cycles. 1870 and 1880 had 11 and 12 articles, respectively; whereas 1890 had but 2 and 1900 was fairly low with 6. 1910 was up to 10 but 1920 and 1930 were again very low.

It seemed desirable to examine the intermediate years in most cases to see whether a series of high or low figures would be sustained by the year midway between. It was found that 1875 had 12 articles which is consistent with the 11 for 1870 and the 12 for 1880. 1895 had 2 which is in line with the 2 for 1890 and not too far removed from the 6 for 1900. 23 articles during 1905 is the highest found for any year studied and seems exceptional. The high number for that year cannot be explained by any special event or discovery as the 23 articles are well distributed as to topics. In counting the 23 articles, the author refrained from including two on animal psychology written by one Peter Rabbit, especially since Peter Rabbit claims to have no intention of establishing scientifically his proposition that animals are able to think. No doubt his articles were inspired by an earlier one of John Burrough's which suggested that animals do not think. Later in the same year William J. Long has an article in which he asserts that animals are able to reason. Times then were not dull for the animal psychologists. 1915 was similar to 1910 but much higher than 1920. This decrease in science articles is well timed to be an effect of World

* Bergen, Catharine, "Science Articles for the Layman," SCHOOL SCIENCE AND MATHEMATICS, Vol. LII, December 1952, pp. 687–693.

War I but it is difficult to be sure or to know why. 1925 is not too far off from the low values of 1920 and 1930. But 1935 is up to 12 which is consistent with the later years but not with 1930. Whatever caused the slump in the 1920's was now over. 1945 was 10, perhaps a little too low as compared with 1940 and 1950. The values are shown in Table 1.

TABLE 1. NUMBER OF SCIENCE ARTICLES IN *Harper's* MAGAZINE

Year	Number of Articles	Year	Number of Articles
1860	3	1915	12
1870	11	1920	2
1875	12	1925	6
1880	12	1930	3
1890	2	1935	12
1895	2	1940	14
1900	6	1945	10
1905	23	1950	17
1910	10	1951	21

Besides the low incidence of science articles in the years following the first World War, there was another low in the 1890's. This too is difficult to explain on the basis of science. Perhaps it is a result not of the lack of science interest but of the excess interest in literature which Henry Seidel Canby describes in his article on the 75th Anniversary of *Harper's Magazine* in Volume 151 of 1925. Canby explains that American authors were somewhat in disrepute when *Harper's* began. That is why the early fiction writers in the magazine were from England—Dickens, Thackeray, Eliot and the like. By 1890 a new crop of American writers was popular. The 1890 and 1895 volumes of *Harper's* are largely, in fact almost entirely, fiction.

Canby, in his Anniversary article already referred to, made a statement of interest in connection with science articles. He writes:

"It was now (1901) that a service to civilization which *Harper's* began in its first numbers reached a development of the highest importance. Science, discovery, and the rapid changes in American political history had run beyond popular knowledge and could no longer be given to the public as news by journalists who were onlookers only."

It is interesting that the year 1901 which Canby singles out seems to occur somewhat near the increase in science articles after the slump of the literary 1890's. One hesitates to explain the 1890's by any scarcity of scientist authors, however, since there seems not to have been any scarcity shortly thereafter. It is noteworthy that prior to 1890, most science articles are listed without names of authors. A few series give the author. It must be added right here that cycles in

Harper's science articles cannot be explained by changes in the Editor-in-Chief.

The distribution of *Harper* articles by topics is presented in Table 2. Articles included in the author's previous study have been incorporated into this table. Topics of low frequency were omitted. The same topics as used in the previous study were taken. It was found, however, that so many *animal* articles occurred in the earlier issues that this topic which is very infrequent in the recent issues had to be

TABLE 2. DISTRIBUTION OF *Harper's* SCIENCE ARTICLES

Topic	Number of Articles per Year																	
	1860	1870	1875	1880	1890	1895	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1951
Physics—incl. meteorology and engines	0	5	0	1	0	0	1½	2	1	0	1	0	0	1	3	3	5	2
Astronomy	0	1	0	0	0	0	½	2	1	0	0	2	0	2	0	1	2	5
Chemistry	0	0	1	0	0	0	0	1	1	0	1	0	0	2	1	1	0	1
Biochemistry	0	0	0	0	0	0	2	0	0	1	0	0	0	2	4	1	4	2
Bacteriology	0	0	0	0	0	0	0	0	2	0	0	0	0	0	1	0	0	2
Geology-incl. oceanography	0	2	1	0	2	0	0	1	1	1	0	0	0	1	0	0	1	3
Paleontology—incl. evolution	0	0	6	0	0	1	1	1	0	0	0	1	0	1	0	1	1	1
Psychology—incl. animal psychology	0	0	0	0	0	0	0	2	1	0	0	0	0	1	1	0	1	1
Animals	3	3	1	9	0	0	1½	6	3	6	0	3	1	1	0	1	0	0
Total*	3	11	12	12	2	2	6	23	10	12	2	6	3	12	14	10	17	21

* Totals include articles on science topics other than those listed above.

added. These are mainly descriptive articles about the appearance, behavior, and habitat of various animals. The year 1880 was marked by the presence of 9 of such articles. The high incidence of paleontology articles in 1875 may be explained by a series called, "The Stone Age in Europe," written by Charles Rau. Physics and biochemistry articles have been more prevalent in the last 15 years. The increase in physics articles is not to be attributed to atomic energy development but more to new developments in aeronautics and rocket ships. The increase in biochemistry articles can be explained on the basis of the recency of the development of the subject itself.

SCIENCE BACKGROUND NEEDED BY READER

It will be recalled that in the *Harper's* science articles for 1950 and 1951, some absolutely could not be understood by a reader without a very good general background in the subject This was particularly true of some astronomy articles. Other articles, as for example in biochemistry, could be partially understood but not completely so by a reader unversed in the subject. In almost all the articles before 1950 no background is even found desirable providing the reader is sufficiently intelligent to understand the explanations given by the author. In 1910 for example, there appeared an article on the struc-

ture of molecules. It included actual structural formulas for organic chemicals but the meaning of the symbolism of a structural formula was explained as though in a beginning text. No actual knowledge was assumed on the part of the reader. At present some writers do not hesitate to include structural formulas in their articles but it would never occur to them to explain the significance of the various parts of the formula. Either the reader must know or he must search elsewhere for that information, or else he must be content not to know. Although the year 1952 was not part of this study, the author noticed that an article on "The Mother Molecules of Life," by George W. Gray makes some previous knowledge of organic chemistry and even of biochemistry highly desirable and perhaps downright necessary. Also in 1952 there is an article on the transistor by Leonard Engel ("Little Gadget with a Large Future") which can probably be understood without a science background but which contains a liberal use of technical terms. The pure layman in this field would not understand the terms but would find them not altogether essential to the main points of the article.

Newsweek

As a matter of interest the author examined *Newsweek* for 1935. In the earlier study the 1950 issues of this periodical had been included. The total number of articles in the year 1935 was about 18% less than in 1950, a not unexpected difference. In analyzing the articles by topics it was found that the number of physics articles and the number of animal articles as well as the number of articles on plants and agriculture were all decidedly fewer in 1935 than in 1950. Articles on other branches did not seem to vary to any great extent.

IMPROVED ELECTROSTATIC GUN IN WESTINGHOUSE TELEVISION TUBES

A new electrostatic gun that improves beam focus in electrostatic television picture tubes has been developed by the Westinghouse Electronic Tube Division. The improved gun will be used in all types of electrostatic television picture tubes manufactured by Westinghouse.

The smaller spot size produced by the new gun gives greater resolution and finer definition. Tubes using the gun show more detail in high-lights while diminishing snow particles. Sharper focus also means the tube is a better performer in fringe areas.

The new gun is less affected by variation in anode and screen grid voltages, permitting the tube to maintain better focus over a wide range of focus voltages.

During the month of June, according to Department of Treasury figures, employment reached an all-time peak of 63.2 million, an increase of 600,000 over June of 1952.

THE IMPACT OF INDUSTRY ON SCIENCE*

DR. GUSTAV EGLOFF

Universal Oil Products Company, Des Plaines, Illinois

Science as we know it today is the outgrowth of industry's recognition of its value in the solution of practical problems. At the beginning of this century, the impact of industry on the accumulation of scientific knowledge began to gain momentum. The present manifestations of its influence on science are many. These effects fall into two general categories, the promotion of research by others and the contributions in scientific facts, machines and materials resulting from industrial research itself.

The most far-reaching effect of industry on science is to be found in its demands for scientific and engineering personnel. By providing jobs for greater numbers of scientists, it also increases the demand for academic presonnel, many of whom in addition to teaching, conduct basic research in their respective scientific and engineering fields. Inasmuch as industry is engaged in research itself, the requirements for scientists and engineers with graduate training are steadily rising. These students are also engaged in research with resultant contributions to scientific knowledge. The growth in demand for industrial personnel is illustrated by the increasing number of schools awarding degrees in chemical engineering. The first bachelor's degree in this field was awarded in 1891. In 1905, one school awarded a Ph.D. In 1921, thirty years after the first degree in chemical engineering was awarded, 42 schools were offering bachelor's degrees, 14 Master's, but only 4 schools conducted training to the Ph.D. level. Last year 53 schools were offering training leading to Ph.D. degrees, 90 to Master's and 113 to bachelor's.

The greatest demands for scientists and engineers, however, have developed since the beginning of World War II. This point is well illustrated by the increases in number of chemists and chemical engineers. During the years from 1939 to 1953, their number has risen from 68,100 to 168,700.

Demands for physicists, mathematicians, engineers in other fields, and biological scientists are also increasing. Developments such as electronic computers require the employment of additional numbers of both physicists and mathematicians in industry. New chemical products, for example, bring about a need for biological scientists to insure against toxic or allergic effects to the persons engaged in operating the manufacturing plant and to the consumers of the prod-

* Presented at the Luncheon of the Annual Convention of the Central Association of Science and Mathematics Teachers, Congress Hotel, November 27, 1953.

ucts. Practically any new development today requires a team composed of scientists from many different fields.

The increase in demand for mathematicians stems not only from their use in the statistical evaluation of laboratory data, the development of machines, chemicals and market evaluation of new products but from the growing trend for industry to apply the methods of the physical sciences to other operations. The new techniques are being used for everything from production scheduling to sales campaigns.

Industry also furthers academic research and stimulates the increase in numbers of scientists and engineers by outright financial support. The growing recognition by industry of the importance of an adequate supply of scientific manpower is resulting in the availability of greater amounts for fellowships, scholarships and financial aid to institutions. Thirty-one companies in the chemical and process industries alone now contribute about $2 million in fellowships and scholarships. Large amounts are also contributed by the electrical, petroleum, pharmaceutical and other industries. A significant trend is greater support at the undergraduate level. Another is the provision of money for the institutions to use in purchase of books and equipment and in other ways to help make up the difference between the tuition charged and the actual cost of the student's education. Some companies provide grants to enable college teachers to do research during summer months. Industrial aid is also being given to programs enabling secondary school teachers to keep up to date. For example, M.I.T. holds a summer program of lectures and laboratory visits for 50 teachers who receive their tuition and $200 for living expenses from the Westinghouse educational foundation. Another kind of program worked out for closer liaison between academic and industrial scientists involves an exchange of personnel. Industrial research men are sent to school while college teachers are employed for a period of time in industrial laboratories. This exchange is most fruitful in broadening the knowledge and perspective of both parties and in the stimulation of new ideas.

Another type of assistance given by industry to science is illustrated by the Fundamental Research Projects of the American Petroleum Institute which receives its financial support from the petroleum industry. These projects were initiated in 1926 by John D. Rockefeller and the Universal Oil Products Company, each giving $250,000. In 1931, the financing and administration was taken over by the A.P.I. The number of projects has increased over the years and include work ranging from the fundamental aspects of the origin of oil and exploration and production of oil to the determination of physical and chemical properties of the individual compounds present in crude oil. Basic research in geology, chemistry, physics and

engineering is conducted. Similar research foundations are supported by the sugar, meat-packing and other industries.

Foundations established through the estates of such wealthy industrialists as Carnegie, Ford, Guggenheim and Rockefeller are also an important source of funds for science. Their contributions are furthering scientific progress not only in the United States but in many under-developed foreign countries.

About two-thirds of the $3.5 billion research program now being conducted in the United States is carried out in industrial laboratories. The projects include not only those for its own needs but many for the government. About 100,000 scientists and engineers are employed in research alone and those in other industrial capacities such as production, control, technical sales, patent and administrative work bring the total scientific personnel employed by industry to about 375,000. This gigantic program results in the contribution of scientific information, engineering principles and other techniques as well as new instruments, machines and materials which are used in furthering the accumulation of scientific knowledge.

Industrial research had its beginnings during the last years of the nineteenth century. Such events as the discovery of the incandescent lamp and the discovery of the Drake Oil Well created problems which had to be solved. In the oil industry, it became apparent during the early years that standardization of products would have to be made and scientists were employed for that purpose. Such problems as the presence of a high percentage of sulfur in some oils brought about the need for actual research within the industry and the employment of a full-time research chemist, Dr. W. M. Burton, in 1889. The electrical industry likewise had problems in the calibration of instruments and employed scientists to deal with them during its early years, but by 1900 it recognized the need for research laboratories. Quoting E. W. Rice, then vice president and technical director of General Electric, "We should not like to assert that the carbon-filament lamp is the best lamp we can have. There may be a better type of electrode for arc lamps than the carbon electrode. These things cannot be determined properly without research." With these beginnings only little more than a half-century ago, industrial research has grown at an accelerating rate. Along with this growth, business executives have become increasingly aware of potentialities in scientific research.

Many companies today find the basis of their major operations in products which were developed through scientific research. One company which started 51 years ago as a rock crushing business, states that at the present time 90 cents out of every sales dollar comes from products developed by research. It now employs 1000 men in re-

search alone, twice the total payroll of twenty-five years ago. Furthermore, to maintain a good competitive position in today's economy, many companies have found that research is an absolute necessity.

Industry's contributions in factual information are in the fields of both basic and applied science. Either through its need to delve more deeply for knowledge associated with a problem or through outright devotion of time to basic research, industry has supplied much in the way of fundamental information. A good illustration is the discovery of the alkylation reaction of paraffins by V. N. Ipatieff and Herman Pines working in the laboratories of the Universal Oil Products Company. Previously it had been the generally accepted belief that paraffins were too inert to undergo such a reaction. This particular discovery is one which was rapidly developed for commercial operation. It is the basis for alkylation processes which made possible 100 octane gasoline without which England could not have won the Battle of Britain in 1940. This discovery also bears directly on the advance of science itself. The initial process utilized sulfuric acid as catalyst but later it was found that hydrogen fluoride offered a number of advantages as catalyst. The development of the use of hydrogen fluoride introduced new concepts into scientific and engineering thinking. This substance had some violent chemical properties which at first seemed to preclude its use in commercial plants. In overcoming these problems, an additional product was made available not only for the oil industry, but for many other industries and for scientific research in general.

The development of techniques through applied research also is of importance both in connection with the problems first at hand and with the progress of science and engineering. The Fluid Flow Catalytic Cracking process used to make gasoline is a good illustration. The fluid technique, which is so named because the powdered solid catalyst resembles a fluid in its behavior, has been applied to processes in many other industries as well as research. It can be used in a wide range of procedures such as the recovery of metals from low grade ores, the manufacture of phthalic anhydride, carbonization of solid fuels, retorting of oil shale, burning of lime, hydrogenation of coal and gas purification.

Science could not have reached its present scope without the precision instruments and machines which are produced by and in many instances developed by industry. Scientific data can be no more precise than the instruments which measure it. The quality of information obtained in both academic and industrial research is constantly improving as a result of the availability of increasingly precise measuring devices. Control of the complex processes used in the oil, chemical and other industries would be impossible without the highly pre-

cise and automatic instruments available today. The Mass Spectrometer is perhaps the outstanding example relating to chemical processes and research. Through its use, minute traces of compounds can be identified and the percentage present determined. Its importance lies not only in analytical measurements but in control of processes. In one operation where absolute vacuum was desirable, whole batteries of Mass Spectrometers were installed. It was the only instrument sufficiently sensitive to detect leaks and without it the operation could not have been conducted.

Good examples of the importance of machines to the progress of science are found in the medical field. Medical science is limited both in treatment of patients and in delving into unsolved problems by inability to make visual observations of many body processes. Special types of cameras have been developed in the past few years for this purpose. One of the more recent is used to photograph the sludging of blood cells. Colored motion picture recording was necessary to illustrate the rapid changes in physical properties of blood cell aggregates. Available cameras, however, were not satisfactory primarily because the maximum light which could be tolerated by the patient was at the minimum intensity for exposure to color film and because the cameras did not permit continuous visualization of the field which in living tissues is in continuous movement. The development of an adequate camera involved cooperation of a wide range of interests, including a medical investigator, an engineer from industry, the American Heart Association, a medical school and a manufacturing company. Although the camera was primarily developed for use in studies through the bulbar conjectiva, which is the outer coating of the eye ball and contains many blood vessels, it has been found equally useful in recording microscopic circulation in other peripheral tissues and internal organs.

The availability of proper tools for research work is all important in the adaptation of a basic idea to a practical product. The concept of television, for example, was known in 1873 but practical development was seriously retarded until the 1930s when electronic methods for making quantitative measurements became available.

The production of material goods and the development of new materials by industry also abet scientific progress. Many chemical and oil companies market high purity compounds for use in research. New materials such as the synthetic fibers and plastics are of great importance to the research scientist. Dynel fiber, for example, is used for filter cloths and chemical-resistant clothing. Polyethylene, because of its great chemical inertness has been applied to many types of equipment. Bottles of polyethylene to replace glass are of particular interest. They are used for the highly corrosive hydrogen

fluoride which etches glass. They are made in many sizes including carboys with the result that great savings in weight are made and danger from breakage is eliminated. Plastic materials also have many highly specific uses in medical treatment and research. The acrylic plastics, for example, are particularly compatible to human tissue and are used for a number of purposes such as bone splints and dentures. Because of its impermeability to water, polyethylene films have applications as for example in a research study of the fluid interchange in the cornea, which requires a watertight separation of the cornea into layers.

While each new industrial product solves one or more problems, it stimulates further research by creating new problems which have to be solved as well as by pointing the way to new areas of investigation having high promise. The synthetic fibers are a good illustration of the creation of new problems. The new acrylic fibers have the advantageous properties of being water and crease resistant because they are plastic in nature. Because of their plastic properties, however, ordinary methods used for dyeing natural fibers could not be applied and new processes had to be worked out so that attractive consumer goods could be produced. The relatively poor draping characteristics of these fibers was another problem which precluded the application of these fibers to many items of clothing. This difficulty is being worked out by blending the synthetics with natural fibers to produce fabrics having the advantageous characteristics of both.

The present high tempo of industrial research assures the continued exponential growth rate of science. The trend to utilize chemicals derived from petroleum, natural gas and coal rather than natural materials such as metals, wood, ceramics, leather, and fibers indicates a future economy dependent on scientists and engineers for its existence. Unfortunately there is a shortage of capable scientists and engineers at present with the result that valuable time is being lost which can never be regained. No amount of money, however large, can get the job done in science and engineering unless brain-power is behind it. Even greater numbers of highly trained men and women will be needed in the years to come. This end can be achieved only if large numbers of our youth are given thorough ground work in mathematics and science beginning at least in secondary schools. The importance of high quality training is greater than ever before.

Rain skirt wraps around milady's waist to ward off rain droplets that get past her umbrella. Useful while grooming pets, working in photographic darkrooms, or boating, the skirt is made of a transparent vinyl plastic film.

SOME PRACTICES USED IN COUNSELING STUDENTS PRIOR TO ENROLLMENT IN ELEMENTARY ALGEBRA AND PLANE GEOMETRY

DAVID J. BLICK AND SHIRLEY E. BRAMAN*
University of Connecticut,
Storrs, Connecticut

It is generally recognized that it is the duty of the public schools to provide educational opportunities that promote the maximum development of all pupils and to guide each youngster into a program that is appropriate for him. A knowledge of mathematics is essential in all programs of training. However, some pupils do not have the aptitude to succeed and profit from the traditional courses in mathematics, and they should be guided to courses which are designed to give them a training in mathematics which will be useful to them. Furthermore, pupils with high aptitude in mathematics need to be encouraged to study it since mathematics is the foundation for advanced work in science and engineering and related fields.

Numerous studies have been made in the last twenty-five years in attempting to predict success in algebra and other secondary school mathematics. These studies have been carefully reviewed by Braman.[1] Apparently there is no one single superior practice or combination of practices for counseling students prior to enrollment in elementary algebra and plane geometry.

The purpose of this study is to describe the current practices that are being used to predict success of pupils in elementary algebra and plane geometry in Connecticut secondary schools. A questionnaire was prepared and mailed in the fall of 1952 to all principals of the secondary schools. This questionnaire was based on a review of the literature and on a pilot study made in twenty-five Connecticut schools in the spring of 1952. The questionnaire included thirteen possible practices that could be used to predict success in elementary algebra and ten possible practices that could be used to predict success in plane geometry. Each school was asked to indicate how each practice was used by checking one of the following: extensively, sometimes, never, and not used but should be. Space was allowed for the insertion of any other practices that were being used. Table 1 shows the number and per cent of returns for each type of school.

* Present address: General Electric Company, Pittsfield, Massachusetts.

[1] Shirley E. Braman, "Practices Used in Connecticut Schools in Counseling Students Prior to Enrollment in Elementary Algebra and Plane Geometry," Master of Science Project, University of Connecticut, Storrs, Connecticut, 1953, Chapter 2, pp. 2–10.

TABLE 2. VARIOUS PRACTICES UESD IN COUNSELING STUDENTS PRIOR TO ENROLLMENT IN ELEMENTARY ALGEBRA

Practice	Classification by Size of School															
	Extensively				Sometimes				Never				Not used, but should be			
	Under 300	300–900	Over 900	Total	Under 300	300–900	Over 900	Total	Under 300	300–900	Over 900	Total	Under 300	300–900	Over 900	Total
Eighth grade arithmetic mark																
Number	13	37	17	67	7	10	2	19	1	5	2	8	0	1	0	1
Per cent	62	70	80	70	33	19	10	20	5	9	10	9	0	2	0	1
Previous year's marks in all subjects																
Number	6	21	10	37	10	21	6	37	5	10	5	20	0	1	0	1
Per cent	29	39	48	39	47	39	28	39	24	19	24	21	0	2	0	1
Eighth grade achievement test scores																
Number	12	29	13	54	6	11	3	20	2	9	4	15	1	4	1	6
Per cent	57	55	62	57	29	21	14	21	9	17	19	16	5	8	5	6
General intelligence test scores																
Number	10	34	14	58	6	9	3	18	4	6	3	13	1	4	1	6
Per cent	47	64	64	60	29	17	14	20	19	11	14	14	5	8	5	6
Battery of aptitude tests scores																
Number	3	7	2	12	1	2	3	6	12	32	15	59	6	12	1	18
Per cent	14	13	10	13	5	4	14	6	57	60	72	62	24	23	5	19
Algebra aptitude test scores																
Number	2	8	4	14	2	4	2	8	7	20	11	38	10	21	4	35
Per cent	10	15	19	15	10	8	10	8	33	40	52	40	47	39	19	37
English test scores																
Number	0	6	5	11	4	6	5	15	14	32	10	55	3	9	1	14
Per cent	0	11	24	12	19	11	24	16	67	60	48	58	14	17	5	14
Rank in eighth grade																
Number	4	11	2	17	8	13	4	25	8	27	14	49	1	2	1	4
Per cent	19	21	10	18	28	25	19	26	28	51	66	52	5	4	5	4
Estimate of pupil's ability to succeed in algebra as judged by:																
Elementary school principal																
Number	3	9	8	20	6	9	5	20	12	34	7	53	0	1	1	2
Per cent	14	17	38	21	28	17	24	21	58	64	33	56	0	2	5	2
Eighth grade teacher																
Number	14	34	16	64	5	12	1	18	2	7	4	13	0	0	0	0
Per cent	67	64	76	67	24	23	5	19	10	13	19	14	0	0	0	0
Secondary school principal																
Number	5	14	5	24	10	7	3	20	6	32	12	50	0	0	1	1
Per cent	24	27	24	25	48	13	14	21	28	60	57	53	0	0	5	1
Guidance Director																
Number	8	31	8	47	5	8	7	20	8	11	5	24	0	3	1	4
Per cent	28	58	38	49	24	15	33	21	28	21	24	25	0	6	5	4
Teacher of algebra course																
Number	6	7	6	19	6	10	1	17	9	35	13	57	0	1	1	2
Per cent	29	13	28	20	29	19	5	18	42	66	62	60	0	2	5	2

TABLE 1. NUMBER AND PER CENT OF SCHOOLS THAT RETURNED THE QUESTIONNAIRE

Type of Schools	Grades	Number of Schools	Number of Returns	Per Cent of Returns
Junior high	7–9	37	30†	81
Six year high	7–12	17	16	94
Four year high	9–12	62	49‡	79
Senior high	10–12	16	8	50
Total		132	103	78

† Includes one school, grades 1–9.
‡ Includes two schools, grades 8–12.

The data obtained from the questionnaire relating to elementary algebra are summarized in Table 2. A classification of this data was also made by type of school organization.[2]

Other practices that were reported are shown in Table 3.

TABLE 3. USE OF OTHER PRACTICES IN COUNSELING STUDENTS PRIOR TO ENROLLMENT IN ELEMENTARY ALGEBRA

Practice	Number of Schools
Vocational and educational plans of student	10
Wishes of parents and students	7
Student curriculum decision	1
Conferences (Between teachers, principal, guidance director, parents, and students)	4
Composite teacher judgment	2
Estimate of ability of student by class counsel or working individually with students	2
Findings of Dean of Boys and Dean of Girls	1
Guidance teachers follow student's work and recommend courses	1
Group guidance classes	1
Anecdotal records	1
English mark, previous year	1

Some of the reasons given for not counseling students are shown in Table 4.

The data relating to plane geometry are summarized in Table 5. A classification of this data was also made by type of school organization.[3]

Table 6 lists other practices that were reported as being used in counseling students prior to enrollment in plane geometry.

Since only six junior high schools reported any counseling for plane

[2] Braman, *op. cit.*, p. 16.
[3] Braman, *op. cit.*, p. 23.

TABLE 5. VARIOUS PRACTICES USED IN COUNSELING STUDENTS PRIOR TO ENROLLMENT IN PLANE GEOMETRY

Practice	Classification by Size of School															
	Extensively				Sometimes				Never				Not used, but should be			
	Under 300	300–900	Over 900	Total	Under 300	300–900	Over 900	Total	Under 300	300–900	Over 900	Total	Under 300	300–900	Over 900	Total
Elementary algebra mark																
Number	9	19	16	44	8	9	2	19	1	3	4	8	0	1	1	2
Per cent	50	59	69	60	44	28	9	26	5	9	17	11	0	3	4	3
Previous year's marks in all subjects																
Number	4	12	11	27	9	12	7	28	4	8	5	17	1	0	0	1
Per cent	22	37	48	37	50	37	30	38	22	25	21	23	5	0	0	1
General intelligence test scores																
Number	7	15	11	33	5	7	6	18	5	9	5	19	1	1	1	3
Per cent	39	47	48	45	28	22	26	25	28	28	21	26	5	3	4	4
Battery of aptitude tests scores																
Number	3	4	4	11	3	3	2	8	5	22	14	41	7	3	3	13
Per cent	17	12	17	15	17	9	9	11	28	69	61	56	39	9	13	18
Geometry aptitude test scores																
Number	0	3	4	7	0	3	1	4	7	11	11	29	11	15	7	33
Per cent	0	9	17	10	0	9	4	5	39	34	48	40	61	47	30	45
Rank in algebra class																
Number	3	10	4	17	7	9	2	18	6	12	15	33	2	1	2	5
Per cent	17	31	17	23	39	28	9	25	33	37	65	45	11	3	9	7
Estimate of pupil's ability to succeed in geometry as judged by:																
Algebra teacher																
Number	11	21	10	42	5	10	8	23	2	1	5	8	0	0	0	0
Per cent	61	66	44	58	28	31	35	31	11	14	16	11	0	0	0	0
Secondary school principal																
Number	7	7	2	16	9	10	5	24	1	14	16	31	1	1	0	2
Per cent	39	22	9	22	50	31	16	33	5	44	69	42	5	3	0	3
Guidance Director																
Number	10	14	10	34	2	8	6	16	5	7	7	19	1	3	0	4
Per cent	56	44	44	46	11	25	26	22	28	25	26	26	5	9	0	6
Teacher of geometry course																
Number	8	11	3	22	5	7	5	17	5	13	15	33	0	1	0	1
Per cent	44	34	13	30	28	22	16	23	28	41	65	46	0	3	0	1

Only six of thirty junior high schools reported any counseling in regard to geometry. These are not included in the table.

TABLE 4. REASONS FOR NOT COUNSELING STUDENTS PRIOR TO ENROLLMENT IN ELEMENTARY ALGEBRA

Reason	Number of Schools
Algebra considered exploratory course—all students take it. Adjustments are made easily during the year	2
All students were allowed to take elementary algebra and adjustments were made easily during the year	1
Elementary algebra, if properly taught, was within grasp of all who attended high school. It offered opportunity to explore mental regions which teachers and pupils needed to explore together	1
Election of college or general course with no electives	1
Counseling done in elementary school	1
No special counseling in choice of subjects	1

TABLE 6. OTHER PRACTICES USED IN COUNSELING STUDENTS PRIOR TO ENROLLMENT IN PLANE GEOMETRY

Practice	Number of Schools
Parent and pupil wishes	7
Educational and vocational plans	6
College Requirement	3
Battery of Achievement Tests	2
Consultation—Deans, Teachers, head of department, parents, pupils	2
Value of course to individual	1
Previous year's English mark	1
Class counselors	1
Testing program organized—local norms gradually being developed for prediction of success in subjects	1
Guidance teachers follow pupils' work and recommended courses	1
College course requirement	1

geometry, the findings for these schools are summarized separately in Table 7.

The important conclusions of the study concerning counseling prior to enrollment in elementary algebra are as follows:

1. The eighth grade arithmetic mark and the estimate of the pupil's ability by the eighth grade teacher were the practices used extensively in most of the schools. The eighth grade achievement test scores and general intelligence test scores were also used extensively in a large percentage of the schools. *Many more schools used these four practices in combination than separately.*
2. The eighth grade arithmetic marks, previous year's marks in all subjects, and the estimate of the pupil's ability by the elementary school principal were used extensively by a greater

TABLE 7

Practice	Extent of Use			
	Extensively	Sometimes	Never	Not used, Should be
Elementary algebra mark	5	1	0	0
Previous year's marks in all subjects	3	3	0	0
General intelligence test scores	4	2	0	0
Battery of aptitude test scores	0	1	4	1
Geometry aptitude test scores	3	0	2	1
Rank in algebra class	0	1	5	0
Estimate of pupil's ability to succeed in plane geometry as judged by:				
Algebra teacher	5	1	0	0
Secondary school principal	0	1	5	0
Guidance director	5	1	0	0
Geometry teacher	0	1	5	0

percentage of large schools than by medium and small schools.

3. General intelligence test scores were used extensively by a greater percentage of medium and large schools than by small schools.
4. The estimate of the pupil's ability by the guidance director was used extensively by the greatest percentage of the medium schools and sometimes by the greatest percentage of the large schools.
5. The estimate of the pupil's ability by the secondary school principal was used extensively by a greater percentage of smaller schools than by larger schools.
6. Eighth grade arithmetic marks, general intelligence test scores, eighth grade achievement test scores, and the estimate of the pupil's ability by the guidance director were used extensively by a greater percentage of junior high schools than by other schools.
7. The estimate of the pupil's ability by the elementary school principal was used extensively by a greater percentage of four year high schools than by junior high schools and six year high schools.
8. Battery of aptitude tests scores and rank in eighth grade were *never* used by a greater percentage of larger schools than by smaller schools.
9. English test scores were *never* used by a greater percentage of smaller schools than by larger schools.

10. Algebra aptitude test scores were *not used*, but it was indicated that they *should be used* by most of the schools.
11. Educational and vocational plans and the wishes of parents and students were the additional practices that were considered most important.

The important conclusions of the study concerning counseling prior to enrollment in plane geometry are as follows:

1. The elementary algebra mark and the estimate of the pupil's ability by the algebra teacher were the practices used extensively in most of the schools. The general intelligence test scores and the estimate of the pupil's ability by the guidance director were also used extensively in a large percentage of the schools. Combinations of these four practices were used more often than a single practice was used.
2. The extensive use of the algebra mark and previous year's marks in all subjects decreased as the size of the schools decreased. A greater percentage of large schools used marks extensively than small schools.
3. A greater percentage of small and medium schools used the estimate of the pupil's ability by the algebra teacher more extensively than large schools.
4. General intelligence test scores were used more extensively by a greater percentage of medium and large schools than small schools.
5. The estimate of the pupil's ability by the guidance director was used extensively in a greater percentage of small schools than medium and large schools and sometimes in a greater percentage of medium and large schools than small schools. This practice was used extensively by a greater percentage of senior high schools and six year high schools than four year high schools.
6. The estimate of the pupil's ability by the geometry teacher was used extensively by small schools more often than by large schools.
7. A greater percentage of large schools *never* used the estimate of the pupil's ability to succeed in geometry by the secondary school principal and rank in algebra class than did small schools. A much greater percentage of the senior high schools *never* used the rank in algebra class than did the other schools.
8. Battery of aptitude tests scores were *never* used in a much greater percentage of medium and large schools than in small schools. This practice was *never* used in a much greater percentage of six and four year high schools than in senior high schools.
9. The geometry aptitude test scores were *not used*, but it was

indicated that they *should be used* in most of the schools.

10. Parent and pupil wishes and vocational and educational plans were considered the most important additional practices.
11. The six junior high schools that reported counseling for plane geometry used a combination of several practices. Elementary algebra mark, previous year's marks in all subjects, general intelligence test scores, estimate of pupil's ability by the algebra teacher and guidance director were used by all of the six schools.

BIBLIOGRAPHY

1. Ayers, G. H., "Predicting Success in Algebra," *School and Society*, 39: 17–18; January 1934.
2. Clifton, L. I., "Prediction of High School Marks in Elementary Algebra," *Journal of Experimental Education*, 8: 410–413; June 1940.
3. Davis, Robert A., and Henrick, Marguerite, "Predicting Accomplishment in Plane Geometry," SCHOOL SCIENCE AND MATHEMATICS, 45: 403–405; May 1945.
4. Dexter, Emily S., "Does Mathematics Require Specialized Endowments?" *School and Society*, 44: 220–224; August 1936.
5. Dicter, M. Richard, "Predicting Algebraic Ability," *School Review*, 41: 604–606; October 1933.
6. Douglass, Harl R., "The Prediction of Success in High School Mathematics," *The Mathematics Teacher*, 28: 489–504, December 1935.
7. Douglass, Harl R., and Kinney, Lucien B., "Prediction of Achievement in Mathematics," *Review of Educational Research*, 8: 51–57; February 1938.
8. Dunn, William H., "The Influence of the Teacher Factor in Predicting Success in Ninth Grade Algebra," *Journal of Educational Research*, 30: 577–582; April 1937.
9. Gibney, E. F., "Aptitude Tests in Relation to the Teaching of Plane Geometry," *The Mathematics Teacher*, 42: 181–186; April 1949.
10. Goddeyne, Sister Loretta Marie, and Nemzek, C. L., "The Comparative Value of Two Geometry Prognosis Tests in Predicting Success in Plane Geometry," *Journal of Social Psychology*, 20: 283–287; November 1944.
11. Grime, Herschel E., "Aptitude and Ability in Elementary Algebra," *School* SCIENCE AND MATHEMATICS, 47: 781–784; December 1947.
12. Grover, C. C., "Results of an Experiment in Predicting Success in First Year Algebra in Two Oakland Junior High Schools," *Journal of Educational Psychology*, 23: 309–314; April 1932.
13. Guiler, Walter S., "Forecasting Achievement in Elementary Algebra," *Journal of Educational Research*, 38: 25–33; September 1944.
14. Hamilton, J. Landon, "A Method of Reducing Failures in Plane Geometry," *Journal of Educational Research*, 30: 700–702; May 1937.
15. Holzinger, K. J. and Swineford, F., "The Relation of Two Bi-Factors to Achievement in Geometry and other Subjects," *Journal of Educational Psychology*, 37: 257–265; May 1946.
16. Hummer, V. L., "A Comparison of IQ and Achievement in Plane Geometry," SCHOOL SCIENCE AND MATHEMATICS, 36: 496–501; May 1936.
17. Jackson, N. A., "Vocabulary in Beginning Algebra," SCHOOL SCIENCE AND MATHEMATICS, 35: 390–394; October 1935.
18. Kellar, Wylma Rose, "The Relative Contribution of Certain Factors in Individual Differences in Algebraic Problem Solving Ability," *Journal of Experimental Education*, 8: 26–35; September 1939.
19. Kraft, O., "Methods Used in the Selection of Pupils for the Study of Algebra and Geometry in Cleveland," *The Mathematics Teacher*, 39: 236–239, May 1946.

20. Layton, R. B., "A Study of Prognosis in High School Algebra," *Journal of Educational Research*, 34: 601–605; April 1941.
21. Lee, J. Murray, and Hughes, W. Hardin, "Predicting Success in Algebra and Geometry, " *School Review*, 42: 188–196; March 1934.
22. Mc Cuen, Theron L., "Predicting Success in Algebra," *Journal of Educational Research*, 21: 72–74; January 1930.
23. Murray, J. E., "Analysis of Geometric Ability," *Journal of Educational Psychology*, 40: 118–124; February 1949.
24. Orleans, Joseph B., "A Study of Prognosis of Probable Success in Algebra and in Geometry," *The Mathematics Teacher*, 27: 225–246; May 1934.
25. Perry, W. M., "Diagnosis of Abilities to Solve Exercises in Geometry," *Journal of Educational Psychology*, 22: 604–609; November 1931.
26. Richardson, H. D., "Predicting Achievement in Plane Geometry," *The Mathematics Teacher*, 28: 310–319; May 1935.
27. Rosilda, Sister Mary., "Is IQ an Index to Algebraic Ability?" *Journal of Educational Research*, 44: 391–393; January 1951.
28. Ross, C. C., and Hooks, W. T., "How Shall We Predict High School Achievement?" *Journal of Educational Research*, 22: 184–195; October 1930.
29. Segel, David, "Measurement of Aptitude in Specific Fields," *Review of Educational Research*, 11: 43; February 1941.
30. Segoe, May V., "Prediction of Achievement in Elementary Algebra," *Journal of Applied Psychology*, 22: 493–503; October 1938.
31. Thurstone, L. L., *Vectors of Mind: Multiple Factor Analysis for the Isolation of Primary Traits*, Chicago: University of Chicago Press, 1935.
32. Torgerson, T. L. and Aamodt, Geneva P., "The Validity of Certain Prognosis Tests in Predicting Algebraic Ability," *Journal of Experimental Education*, 1: 277–279; March 1933.

MICHIGAN COUNCIL OF TEACHERS OF MATHEMATICS FIFTH ANNUAL CONFERENCE

April 30, May 1, and May 2, 1954

The fifth annual conference of the Michigan Council of Teachers of Mathematics will be held at St. Mary's Lake Camp, near Battle Creek, on April 30, May 1, and May 2, 1954. Registration will be held on Friday afternoon, April 30, and the meeting will close with dinner on Sunday, May 2.

The program committee has designated "Developing Interest in Mathematics" as the theme of the conference. Professor Maurice L. Hartung of the University of Chicago and Professor J. Sutherland Frame of Michigan State College will be guest speakers. Dr. Hartung will serve as consultant throughout the conference. There will be exhibits, demonstrations, and discussion groups prepared or conducted mainly by classroom teachers from Michigan schools. The topics for the discussion groups cover a wide range of interests from the arithmetic of the elementary grades to the mathematics of the junior college.

In addition to the fine program which is being prepared, the camp affords excellent recreational facilities. This is the best opportunity Michigan affords for its mathematics teachers to get acquainted, exchange ideas, and have a good time together. All mathematics teachers, whether in public or private schools, are invited to attend for the full duration of the conference or for as much of it as they can.

The camp is beautifully located on St. Mary's Lake. It has accommodations for about 150 persons. Meals are served in the main dining hall and there are dormitory-type sleeping accommodations. The charge is modest. The best way to be assured of accommodations is to send in reservations early. Inquiries and reservations may be sent to Miss Bertha Schermer, Grosse Pointe High School, Grosse Pointe, Michigan.

THE AAAS COOPERATIVE COMMITTEE ON THE TEACHING OF SCIENCE & MATHEMATICS

A REPORT ON RECENT ACTIVITIES

The Cooperative Committee was organized in 1941 by representatives of several scientific societies to work on educational problems the solution of which can be attained better by cooperative action than by any single scientific group working alone. Initially consisting of the representatives of five professional societies in several fields of science and science teaching, the Committee has grown to include representation from eighteen professional organizations. The present Committee chairman is Morris Meister, Bronx High School of Science, and the secretary is Bernard B. Watson, Operations Research Office, Johns Hopkins University.

The member societies and their representatives are:

American Association of Physics Teachers: Bernard B. Watson, Operations Research Office, Johns Hopkins University.
American Astronomical Society: Thorton Page, Operations Research Office, John Hopkins University
American Chemical Society: C. H. Sorum, University of Wisconsin
American Geological Institute: Arthur L. Howland, Northwestern University
American Institute of Physics: J. W. Buchta, University of Minnesota
American Nature Study Society: Richard L. Weaver, University of Michigan
American Society for Engineering Education: Milton O. Schmidt, University of Illinois
American Society of Zoologists: L. V. Domm, Loyola University, Chicago
Botanical Society of America; Glenn W. Blaydes, Ohio State University
Central Association of Science and Mathematics Teachers: Donald W. Lentz, Parma (Ohio) Public Schools
Division of Chemical Education of the American Chemical Society: Laurence L. Quill, Michigan State College
Executive Committee of the AAAS: Duane Roller, Hughes Aircraft Company
Mathematical Association of America: J. R. Mayor, University of Wisconsin
National Association of Biology Teachers: Prevo L. Whitaker, Indiana University
National Association for Research in Science Teaching: George G. Mallinson, Western Michigan College of Education
National Council of Teachers of Mathematics: George E. Hawkins, Lyons Township Hhigh School and Junior College, LaGrange, Illinois
National Science Teachers Association: Morris Meister, Bronx High School of Science
Section Q (Education), AAAS: Francis D. Curtis, University of Michigan

The Committee has given its attention to a number of major problems in the fields of science and mathematics teaching at the elementary, secondary, and higher educational levels. It has prepared and published reports embodying its views and recommendations in connection with these problems.

During the war the Committee issued a report on "High School

Science and Mathematics in Relation to the Manpower Problem." Shortly after the termination of the war it issued a report on "The Preparation of High School Science and Mathematics Teachers," recommending improved certification standards for teachers in these fields.

Among its most ambitious projects have been the preparation of two reports at the request of governmental bodies. One was prepared for UNESCO as an aid in rebuilding the instructional laboratories of the devastated nations of Europe and was concerned with the nature and organization of American science education, with particular reference to instructional equipment. The other was prepared at the request of Dr. John R. Steelman, Chairman of the President's Scientific Research Board, and was concerned with "The Present Effectiveness of Our Schools in the Training of Scientists." It appeared as Appendix II (pp. 47–119) of Volume four of "Science and Public Policy" (Steelman Report), a report to the President by the President's Scientific Research Board.

Another activity of the Committee has been the sponsorship at each Annual Meeting of the AAAS of a symposium on some aspect of science teaching. In addition, each fall for the past three years, the Committee has collaborated with the U. S. Office of Education in arranging a conference to which are invited representative school administrators and science teachers for an exchange of views on some important problem in science education or in the preparation of science teachers.

During the past year the Committee has been concerned with the development, improvement and utilization of techniques for the early recognition of science talented youth. It has been concerned also with the improvement of the quality of educational experiences provided for such young people. The last joint conference of the Cooperative Committee and the U. S. Office of Education addressed itself to this general theme, and following that conference the Committee issued a statement of its views in connection with the training of personnel with high level ability in the fields of science and mathematics. The Committee believes

1. That the proper development of such personnel is essential to the welfare of the nation; especially so, in view of the critical shortage of scientists and engineers, the present and anticipated demands of a technological age, and the state of international tension.
2. That equality of educational opportunity is basic to democracy; and that that implies an opportunity for every individual to attain his own maximum achievement.
3. That we cannot afford to continue the resulting loss to society in high quality human resources and creative contributions.
4. That current general practices for identifying and developing students with high aptitude in science and mathematics are inadequate.

5. That many tested and successful practices *are* being used for the early identification and proper development of students with high aptitude. These practices should be made widely known.
6. That schools and colleges be urged to modify administration, curricula, guidance and teaching facilities and procedures so as to facilitate the widespread use of these successful practices.
7. That inadequate educational provisions for youth of high promise cause difficulties in coordinating school and college education.
8. That teacher training institutions and school systems should give greater recognition to the need for teachers qualified to teach students of top-level ability.

A further activity of the Committee reflecting its concern for the education of students of high ability has been its review of the courses of study in the sciences and mathematics prepared in connection with the Ford Foundation's School and College Study of Admission with Advanced Standing. The School and College Study is seeking to provide an enriched educational experience for students of high academic ability while achieving, at the same time, a reduction in the total time required for such students to complete their high school and college work.

BERNARD B. WATSON, *Secretary*
Reported by DONALD W. LENTZ

THE KELLOGG GULL LAKE BIOLOGICAL STATION

One of America's most scenic and diversified biological stations will begin classes and research in 1954 at Michigan State College's Gull Lake property near Battle Creek, Mich.

Site for the permanent station is the 32-acre landscaped estate which formerly served as a summer home for W. K. Kellogg, Battle Creek cereal manufacturer and philanthropist who died in 1951.

The new station will be known formally as "The Kellogg Gull Lake Biological Station of Michigan State College."

Adjoining the picturesque estate in Central Michigan's "Water Wonderland" are 1,500 acres of land given to the university by Mr. Kellogg in 1930. Included in this property are a bird sanctuary, farms and forests supervised by C. N. McCrary of the M.S.C. staff, and lakes, ponds, and streams.

The 32-acre estate which will serve as headquarters for the station was given to M.S.C. by the Kellogg Foundation following World War II. This year an additional grant of $45,000 was given to M.S.C. by the Foundation to remodel facilities of the estate for use as the biological station and to acquire certain basic equipment.

"The large range of facilities and conditions at the estate and adjoining grounds will provide Michigan State College with one of the most diversified stations of its kind in America," said Dr. H. J. Stafseth, head of M.S.C.'s Division of Biological Science and station director.

Courses will be offered at the station for the first time in the summer of 1954. The courses are expected to be especially appealing to elementary school teachers as well as to graduate and undergraduate biology students.

Courses of instruction will include nature study, botany, zoology, entomology, parasitology, bacteriology, fisheries and wildlife. Research is to be conducted year-round at the station.

FINAL REPORT TO THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS OF ITS COMMITTEE ON THE SIGNIFICANCE OF MATHEMATICS AND SCIENCE IN EDUCATION*

GEORGE GREISEN MALLINSON, *Chairman*
Western Michigan College of Education, Kalamazoo, Michigan

WALTER G. MARBURGER
Western Michigan College of Education

DAVID J. MILLER
Lakeview Junior High School, Battle Creek, Michigan

GERALD OSBORN
Western Michigan College of Education

DONALD WORTH
Lincoln Junior High School, Kalamazoo, Michigan

INTRODUCTION

On July 18, 1950, Mr. Allen F. Meyer, President of the Central Association of Science and Mathematics Teachers contacted the chairman and asked him to head a committee being formed "to study ways and means of bringing to the attention of the community the importance of the place of science and mathematics in education."

A clarification of certain assumptions made by the Policy and Resolutions Committee appears in a letter from President Meyer as follows:

"May I also call your attention to gaps in education which led to the decision to create this new Committee? It has been noted that the enrollment is light in Physics, Chemistry, Elementary Science, Trigonometry, Advanced Algebra, and Solid Geometry. It has been noted that the adult public paying the bill is alerted to other fields of learning leaving Mathematics and Science to be taken for granted, resulting in a regrettable lack of balance in the curriculum, a looming disappointment for graduates. In my opinion the non-school public should not learn the hard way. Some public relations in this area will result in the kind of thinking essential to wise election of courses by school children. Recreational courses have their place, to be sure, but they should not be permitted to drive the basic courses, which make recreation possible, from the curriculum of any child."

After a number of communications the above named committee

* Presented at the Annual Meeting of the Central Association of Science and Mathematics Teachers at the Congress Hotel, Chicago, Nov. 28, 1953.

was appointed. Two preliminary meetings were held by the committee on October 20, 1950 and November 9, 1950. At the meeting of the Central Association of Science and Mathematics Teachers in Chicago in November 1950, the chairman reported on progress to Mr. Kenneth Vordenberg, then Projects Coordinator of the Policy and Resolutions Committee Projects. It was agreed that it would be futile to make a mere listing of recommendations for ways in which to publicize the significance of mathematics and science in order to stimulate enrollments. It was agreed, however, that a series of recommendations based on an analysis of underlying causes might prove to be of great value. Hence, it was decided that the committee should be given latitude to develop the project in harmony with these latter two considerations.

During the two months following the Chicago Convention of 1950 a number of committee meetings were held. In these early deliberations the committee decided that the problem should be attacked in the following three stages:

I. The determination of whether the reported drop in enrollments in mathematics and science is real or imaginary.

II. If the drop were found to be real, the determination of the causes, in so far as possible.

III. If causes could be identified, a presentation of some recommendations that might help to reverse the downward trend in enrollments.

At the outset the committee realized that the extent and implications of the project were far-reaching. It recognized further that finances were relatively unavailable and that time and effort given by committee members to this project would be in addition to that expended in teaching duties. Consequently, it was decided to keep the amount of original research for the project to a minimum. It was also decided to gather information and data needed to consummate the charge given to the committee from investigators and organizations that had already attacked certain phases of the problem. More than one-half of the information and data in this report were obtained this way.

Stage I: The Reality of the Drop in Enrollments in Science and Mathematics.

Science

A search of the literature revealed five reports that contained information concerning enrollments in science over the last five decades. These reports follow:[1]

[1] Credit is due the Office of Education and Drs. Kenneth E. Brown, Specialist for Mathematics and Philip G. Johnson, formerly Specialist for Science for assistance in various ways and for permission to use freely any and all information they sent.

1. Johnson, Philip G., "A Report On School and Science Enrollments in Identical Schools During the Fall of 1947 and the Fall of 1952." Unpublished duplicated report presented to the Convention of the National Association for Research in Science Teaching in Atlantic City, New Jersey, February 16, 1953.
2. Johnson, Philip G., *The Teaching of Science in Public High Schools*. Bulletin 1950, No. 9, Office of Education, Federal Security Agency, Washington, D. C., 1950, Pp. viii+48.
3. National Survey of Secondary Education, *The Program of Studies*. Bulletin 1932, No. 17, Monograph No. 19, Office of Education, United States Department of the Interior, Washington, D. C., 1933. Pp. x+340.
4. *Offerings and Enrollments in High-School Subjects, 1948–49*. Chapter 5, Biennial Survey of Education in the United States in 1948–50. Office of Education, Federal Security Agency, Washington, D. C., 1951. Pp. vi+118.
5. Rice, Mabel C., *National Summary of Offerings and Enrollments in High-School Subjects, 1948–49*. Statistical Circular, Circular No. 294, Office of Education, Federal Security Agency, May 1951 (unpaged).

The data from these sources clearly indicated two facts:

1. Enrollments had grown both numerically and percentage-wise in some science courses and had dropped both numerically and percentage-wise in others.

2. Numerical differences alone were unreliable measures of changes in course enrollments, since during the decades with which this report was concerned, the high-school population had increased greatly. It was decided, therefore, to deal with science enrollments in terms of percentages. Table I, that follows, developed from the data from the above mentioned sources, indicates clearly the trends in science enrollments.

TABLE I. PER CENT OF HIGH-SCHOOL PUPILS ENROLLED IN SCIENCES FROM 1890–1952

Year Reported	Ninth-grade General Science	Biology	Chemistry	Physics	Other Sciences
1890	—	—	10.10	22.21	—
1895	—	—	9.15	22.77	—
1900	—	—	7.72	19.04	—
1905	—	—	6.76	15.66	—
1910	—	—	6.89	14.61	—
1915	—	6.90	7.38	14.23	—
1922	18.27	8.78	7.40	8.93	—
1928	17.50	13.58	7.07	6.85	—
1934	17.75	14.60	7.56	6.27	—
1947[a]	18.32	19.51	8.62	5.49	—
1948–49	20.80	18.40	7.60	5.40	2.30
1952[b]	19.40	20.40	7.60	4.30	3.80

[a] The Teaching of Science in Public High Schools, Bulletin 1950, No. 9. (Data for school year 1947–48.)
[b] Data reported in 1952 by same schools that reported in 1947–48.

Using the year 1922 as a reference point, there has been only a

small percentage-wise change in enrollments in ninth-grade general science. However, enrollments in biology have more than doubled. Those in chemistry have remained fairly stable, while those in physics have dropped to slightly less than half. It is interesting to note that the decline in physics from 1948–9 to 1952 is paralleled by a similar percentage-wise increase in enrollments in "other sciences." The growth in enrollments in "other sciences" refers chiefly to the growth in enrollments in general physical science, according to *Offerings and Enrollments in High-School Subjects, 1948–49*. Although it is not indicated by this table, it is well known that specialized courses such as botany, zoology, physiography, meteorology and astronomy have disappeared almost entirely from the high-school curriculum. Thus it may be seen that there has been a growth in the percentage of students taking the generalized courses in high-school science and a decrease in percentages of those taking the more specialized courses, other than chemistry.

Mathematics

The problem of determining the reality of a drop in enrollments in the field of mathematics was more difficult than for the field of science. There were no publications in mathematics comparable with those used to detect changes in science enrollments. Hence, some other procedure had to be devised. Letters were sent to Dr. John Mayor, University of Wisconsin; Dr. Harold Fawcett, The Ohio State University; Dr. Howard Fehr, Teachers College, Columbia University; and Mr. Harry Charlesworth, then Acting Executive Secretary of the National Council of Teachers of Mathematics, now of East High School, Denver, Colorado, requesting information concerning research studies dealing with enrollments in mathematics over the years. These individuals indicated that they had no information of direct value either.

Hence, on October 25, 1951 letters were sent to the State Departments of Public Instruction of all the states requesting any information available concerning "the number of students enrolled in the various mathematics courses in your state for the past thirty years." It was further stated that we "should also like to know for the same period the total high-school enrollments in your state, so that we could compute any percentage-wise fluctuations."

Replies were received from all the states. Although the vast majority indicated that for one reason or another, the data were not available, a number of states did provide information. Because no two submitted data in the same form it was necessary to group the items of data as well as possible and to prepare a table that would show any shifts in enrollment.

It was not deemed desirable to tabulate data for all the courses in high school since the number would have been far too great for the scope of this report. Therefore, only enrollments in the "standard" courses in mathematics were used in these tabulations. States that had data available for a long period are grouped in Table II, those for a short period in Table III.

While it is obvious that these data are not sufficient to prove a national trend, they tend to show that in some states (1) there have been decreases in enrollments in the specialized courses, (2) there have been few cases of significant increases in the specialized courses, and (3) there have been increases in enrollments in the generalized courses. There have been, of course, periods during which both upward trends and downward trends have been temporarily reversed. Trigonometry is an exception among the specialized courses, since it has increased somewhat in enrollments.

These findings in general substantiate the following statement found in the *Biennial Survey of Eeucation in the United States, 1948–49*:[2]

"The only mathematical subjects to show percentage increases in enrollment in 1949 are general mathematics . . . and trigonometry. . . . The former increased to 13.1 per cent from 7.4 per cent in 1934, and trigonometry was at an all-time high of 2 per cent in 1949."

It is the conclusion of this committee that while total enrollments in both mathematics and science are increasing, enrollments in the specialized courses, in both of these fields have in some cases declined percentage-wise. At any rate there have not been the increases that are commensurate with the increasing needs for specialists in these areas. Thus the drop in enrollments in the sense just indicated is accepted as a reality.

Stage II: The Causes for the Drops in Enrollments in Mathematics and Science.

It is obvious that the drops in enrollments in the specialized courses in mathematics and science are significant in one respect. The courses in which enrollments are decreasing are ordinarily elective, while those in which enrollments are increasing are ordinarily required.

The next step then was to determine, in so far as possible, the factors that might be related to, or the cause of, such a phenomenon. A search of the literature was made to locate research studies that might bear on the problem. Where research studies were not available the members of the committee carried out the necessary investigations. The discussions that follow review the research studies that are related to the problem:

---

[2] *Op. cit.*, p. 16.

TABLE II. PERCENTAGE OF HIGH-SCHOOL

Year	State Supplying Data											
	Missouri							New York*				
	Alg.	Adv. Alg.	Pl. Geom.	Sol. Geom.	Adv. Arith.	Trig.	Gen. Math.	Int. Alg.	Adv. Alg.	Pl. Geom.	Sol. Geom.	Trig.
1913–14	52.7	1.1	22.7	4.6	5.0	1.9	—	—	—	—	—	—
*												
*												
*												
1928–29	—	—	—	—	—	—	—	8.9	1.0	15.4	1.2	1.6
1929–30	—	—	—	—	—	—	—	8.8	1.1	15.4	1.1	1.8
1930–31	—	—	—	—	—	—	—	8.8	1.1	15.4	1.2	2.0
1931–32	—	—	—	—	—	—	—	8.1	1.0	14.9	1.1	2.1
1932–33	—	—	—	—	—	—	—	8.2	0.9	13.3	1.1	2.1
1933–34	—	—	—	—	—	—	—	7.9	0.8	12.6	0.9	2.0
1934–35	—	—	—	—	—	—	—	7.6	0.7	12.5	0.8	2.0
1935–36	—	—	—	—	—	—	—	7.4	0.6	12.6	0.7	2.0
1936–37	—	—	—	—	—	—	—	7.4	0.6	12.0	0.7	1.9
1937–38	—	—	—	—	—	—	—	7.4	0.6	11.7	—	—
1938–39	—	—	—	—	—	—	—	7.0	0.7	10.7	0.8	2.1
1939–40	—	—	—	—	—	—	—	7.3	0.8	10.1	0.9	2.3
1940–41	—	—	—	—	—	—	—	7.1	0.8	10.2	0.9	2.5
1941–42	—	—	—	—	—	—	—	7.7	0.9	11.2	1.0	2.7
1942–43	—	—	—	—	—	—	—	8.2	1.0	11.4	1.2	3.2
1943–44	—	—	—	—	—	—	—	8.6	1.0	11.5	1.4	3.7
1944–45	22.5	4.2	10.2	1.3	0.6	1.9	19.1	8.5	1.1	11.6	1.4	3.4
1945–46	—	—	—	—	—	—	—	8.6	1.1	12.4	1.3	3.5
1946–47	—	—	—	—	—	—	—	9.4	1.2	12.9	1.6	3.7
1947–48	—	—	—	—	—	—	—	11.0	1.5	13.0	1.8	4.2
1948–49	—	—	—	—	—	—	—	9.7	1.4	11.1	1.6	4.1
1949–50	16.2	2.5	6.6	0.7	—	1.1	20.0	9.0	1.4	11.4	1.4	4.0
1950–51	—	—	—	—	—	—	—	—	—	—	—	—

* Based on number of Regents Examinations.

TABLE III. PERCENTAGE OF HIGH-SCHOOL

Year	State Supplying Data											
	Minnesota						Vermont					
	El. Alg.	Pl. Geom.	Sol. Geom.	Gen. Math.	Higher Alg.	Trig.	El. Alg.	Higher Alg.	Pl. Geom.	Sol. Geom.	Trig.	Gen. Math.
1939–40	7.5	11.9	0.8	0.5[a]	3.1	1.9[a]	—	—	—	—	—	—
1940–41	—	—	—	—	—	—	—	—	—	—	—	—
1941–42	—	—	—	—	—	—	—	—	—	—	—	—
1942–43	—	—	—	—	—	—	—	—	—	—	—	—
1943–44	—	—	—	—	—	—	—	—	—	—	—	—
1944–45	—	—	—	—	—	—	—	—	—	—	—	—
1945–46	—	—	—	—	—	—	15.8[c]	5.9	7.7	2.2	1.6	10.4
1946–47	—	—	—	—	—	—	14.8	5.7	8.1	1.0	2.0	10.1
1947–48	—	—	—	—	—	—	—	—	—	—	—	—
1948–49	15.7	8.1	1.4	6.1	0.6[b]	1.3	12.8	5.2	7.1	0.8	1.7	10.3
1949–50	—	—	—	—	—	—	12.8	5.5	6.5	0.5	1.2	11.2
1950–51	—	—	—	—	—	—	—	—	—	—	—	—

[a] Estimates from data available.
[b] Estimate from data available.
[c] Computations for 1945–46 based on best figures available.

STUDENTS TAKING COURSES IN MATHEMATICS

State Supplying Data

Oregon							New Jersey						
Int. Alge.	Adv. Alg.	Pl. Geom.	Sol. Geom.	Trig.	Gen. Math.	Senior Math.	Gen. Math.	Alg.	Pl. Geom.	Sol. Geom.	Trig.	Int. Alg.	Adv. Alg.
—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	1.5	29.4	13.3	2.0	2.1	—	—
14.63	2.51	9.82	1.16	0.65	0.99	—	—	—	—	—	—	—	—
14.10	3.00	9.10	1.10	0.80	2.20	—	—	—	—	—	—	—	—
14.50	2.50	9.20	1.20	0.50	2.30	—	—	—	—	—	—	—	—
19.92	3.80	12.66	1.32	1.42	5.31	—	4.1	25.8	10.7	1.8	2.0	—	—
18.59	3.69	11.28	1.34	1.82	6.34	—	—	—	—	—	—	—	—
19.43	3.63	11.35	1.31	1.58	6.02	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—
13.05	2.89	9.51	1.25	1.45	11.28	—	6.5	21.7	9.3	1.6	2.1	—	—
13.10	2.84	8.17	1.01	1.40	12.10	—	—	—	—	—	—	—	—
13.13	2.30	8.17	1.02	1.23	13.61	—	—	—	—	—	—	—	—
14.12	2.17	7.43	0.83	1.34	14.06	—	—	—	—	—	—	—	—
12.82	2.47	7.33	0.92	1.09	15.21	0.34	8.8	21.0	9.6	1.9	2.2	—	—
14.42	2.97	7.51	0.97	1.54	18.95	1.08	—	—	—	—	—	—	—
18.62	3.96	6.61	1.30	1.79	21.27	1.05	—	—	—	—	—	—	—
16.46	3.38	7.89	0.39	1.71	21.17	0.77	—	—	—	—	—	—	—
15.44	2.76	6.26	0.55	1.39	19.86	0.99	21.4	14.6	15.8	2.7	2.7	7.7	1.3
15.48	3.07	6.86	0.69	1.49	21.72	0.92	—	—	—	—	—	—	—
14.70	2.38	6.37	0.73	1.48	21.86	1.37	—	—	—	—	—	—	—
14.93	2.47	5.43	0.72	1.54	22.12	0.55	—	—	—	—	—	—	—
15.84	3.20	5.97	0.84	1.12	22.02	0.36	8.5	14.0	10.1	2.1	2.6	7.3	0.9
—	—	—	—	—	—	—	8.1	14.1	10.3	1.8	2.4	7.2	0.9

STUDENTS TAKING COURSES IN MATHEMATICS

State Supplying Data

Nebraska							Montana						
Gen. or App. Math.	Int. Alg.	Pl. Geom.	Adv. Alg.	Senior Math.	Sol. Geom.	Trig.	Gen. Math.	Adv. Math.	Alg.	Adv. Alg.	Sol. Geom.	Pl. Geom.	Trig.
—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	3.6	—	10.9	3.5	0.5	13.0	0.8[d]
—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	4.5	0.8	25.6	—	0.6	16.1	0.8[e]
—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—
11.3	19.4	14.1	3.7	1.9	0.3	0.8	—	—	—	—	—	—	—
12.0	21.0	13.1	3.8	2.0	0.2	0.3	—	—	—	—	—	—	—
—	—	—	—	—	—	—	8.2	1.0	22.4	0.7	0.1	13.8	0.3[e]

[d] Based on approximate high-school population of 32,000.
[e] Based on approximate high-school population of 30,000.

A. *How do the interests of students in mathematics and science change at the high-school level?*

A study undertaken by Crumrine,[3] although not centered on mathematics and science, does provide evidence concerning the topic of this investigation. In his study he administered the Kuder Preference Record, Form BB, to 240 high-school students at the ninth-grade level and again to these same students after they had completed three years of high school. He then compared the scores they made at the two levels in order to determine the extent to which the various areas of interest changed during high-school. However, Crumrine's study leaves unanswered a major question related to the problem of this report, namely, the extent to which interest in the specific areas of mathematics and science change during high school. Thus, the following question was posed, "Are mathematics and science areas in which interests *do* remain stable during the high-school period?"

Mallinson and Van Dragt[4] used the data obtained by Crumrine to investigate specifically the stability of interest in mathematics and in science. The first step was to prepare scatter tables for the ranks of the scores in interest received by the students in these two areas at both the ninth- and twelfth-grade levels.

The next step was to compute from the raw scores obtained in interest in mathematics and in science the number of cases in which the raw scores for the interest areas increased between grades IX and XII, the number of cases in which they decreased, and the number of cases in which they remained the same.

Table IV indicates the results of these computations:

TABLE IV. CHANGES IN RAW SCORES RECEIVED IN MATHEMATICS AND IN SCIENCE INTERESTS AT GRADES IX AND XII

Area of Interest	Number of Cases of Increase	Number of Cases of Decrease	Number of Cases In Which Score Remained Same
Science	112	115	13
Mathematics	111	125	4

It was then decided to repeat the previous computations, using the ranks of the scores instead of the raw scores. Table V contains these computations. See top of the following page.

Tables IV and V contain evidence that tends to show that interests of high-school students in mathematics and/or science do not remain stable during the high-school period. It is, of course, not surprising to

[3] Crumrine, William M., "An Investigation of the Stability of Interests of High-School Students." Unpublished master's thesis, University of Michigan, 1949.

[4] Mallinson, George Greisen and Van Dragt, Harold, "Stability of High-School Students Interests in Science and Mathematics." *School Review*, LII (September 1952), 362–7.

TABLE V. CHANGES IN RANKS OF AREAS OF INTEREST IN MATHEMATICS AND SCIENCE AT GRADES IX AND XII

Area of Interest	Number of Cases of Increase	Number of Cases of Decrease	Number of Cases In Which Score Remained Same
Science	93	89	58
Mathematics	83	94	63

note that the scores obtained on the test change. It is surprising, however, to note the percentages of cases in which the relative ***rank*** of interests in mathematics and science, as compared with other interests, change during high-school.

Table V indicates that only in about one-quarter of the cases do the ranks of the areas of interest remain constant. In about one-half of the remaining cases the ranks increased, and in about one-half decreased. Hence, it would seem that it is not justifiable to assume that interests in these areas at the beginning of high school will necessarily increase as the student passes through high school. Such interests apparently are just as likely to wane.

It is possible that drops in enrollments at the high-school level in certain higher courses in mathematics and science may be due partly to the fact that educators have overlooked the necessity for stimulating interest in these subjects and motivating students in these areas. Apparently the intrinsic value of the courses is not sufficient to motivate the students to elect them.

B. *Are teachers of mathematics and science sufficiently well trained to stimulate students to elect courses in these areas?*

The "proof of the pudding" is, of course, in the eating. The characteristic in a teacher of "being well trained" probably is best determined by how successful that teacher is in the classroom. But, this criterion for success is nebulous and is dependent on such a vast number of variables that it would have been impossible to investigate this facet of the problem with the time, money and personnel available.

However, it was decided that it would be possible to obtain evidence (1) on the extent to which teachers of mathematics and/or science have adequate subject-matter backgrounds in these fields, and (2) on the requirements in mathematics and/or science for certification to teach these subjects. A number of research studies had already been carried out in these areas and it was possible to draw certain conclusions from them.

Science

[*]A series of six studies was undertaken by Mallinson and

others[5,6,7,8,9,10] that deal with the training of science teachers, two of them being in the area of elementary science.

One of these investigations in elementary science involved on analysis of the subject-matter backgrounds and science competencies of critic teachers in colleges and universities, while the other dealt with the requirements in science set up for the elementary certificate.

Those studies revealed that critic teachers at the elementary-school level (1) lack adequate backgrounds in subject matter and methods in science, (2) are frequently unfamiliar with the equipment used for science demonstrations, and (3) frequently treat science experiences as being incidental and contributory to the program of social studies. Further it was found that in thirty-two states it was possible for a teacher to be certified to teach in the elementary grades without having had any courses in science, and that in forty-three states it was possible to act as a specialist or consultant in the teaching of elementary science without having had any academic credit in science.

The four other studies deal with various aspects of the subject-matter competencies of, and certification requirements for, teachers of high-school science. In one investigation four tests of equivalent difficulty in the fields of Biology, Chemistry, Earth Science and Physics were developed and administered to seventy-nine student teachers who had majored in science in five state teachers colleges and in one university school of education in the Midwest. The scores they obtained on the various areas were then analyzed for the reliabilities of their differences. In the second study the same tests were administered to high-school pupils who were "majoring" in science. Eighty-three pupils from five high schools with enrollments below two hundred fifty contributed usable test papers. The scores obtained by the high-school pupils were then compared with those obtained by the student teachers.

In the third investigation the scores obtained on the various tests by the student teachers were compared with the numbers of credit hours of science they had taken in the respective areas of science.

The fourth study of the series was similar to one undertaken by

---

[5] Mallinson, George Greisen, "A Comparison Between the Scores Obtained on A Science Achievement Test by Student Teachers in Science and by High-School Pupils." SCHOOL SCIENCE AND MATHEMATICS, XLIX (December 1949), 731–6.

[6] Mallinson, George Greisen, "An Investigation of the Subject-Matter Backgrounds of Student Teachers in Science." SCHOOL SCIENCE AND MATHEMATICS, XLIX (April 1949), 265–72.

[7] Mallinson, George Greisen, "Preparing Critic Teachers To Supervise and Teach Elementary Science." *Science Education*, XXXII (October 1948), 238–42.

[8] Mallinson, George Greisen, "State Requirements for Certification of Teachers of Elementary Science." *Science Education*, XXXIII (October 1949), 289–91.

[9] Mallinson, George Greisen, "State Requirements for Certifying Teachers of High-School Science." SCHOOL SCIENCE AND MATHEMATICS, LI (October 1951), 543–56.

[10] Mallinson, George Greisen and Sams, Conway, "An Investigation of the Subject-Matter Competence of Student Teachers in Science." SCHOOL SCIENCE AND MATHEMATICS, LI (June 1951), 461–9.

Pruitt.[11] In both studies the requirements in science for certifying teachers of high-school science were determined. Pruitt's study, however, covered all fields while Mallinson's dealt only with the field of science. In both studies the requirements were listed for each state and were then summarized. In Mallinson's study the requirements were compared with the suggestions for certification made by various professional organizations.

The findings of these studies indicated that (1) teachers are invariably trained significantly better in one field of science than in the others; (2) although beginning teachers usually teach generalized courses in science, and in small schools may teach all the science, their training in science is not suited to such teaching; (3) that the subject-matter competencies of new science teachers tend to be factual rather than centered around the ability to apply and make use of scientific information; (4) there is little uniformity in state requirements for certifying teachers of science, since at least seven states have not established requirements while others demand as much as forty semester hours to teach in certain areas of science; (5) there seems to be little evidence that certifying agencies have considered the qualifications desirable for supervisors or consultants in the areas of science; and (6) a comparison of state requirements with the recommendations of various authoritative bodies indicates that in general there are great discrepancies between what is considered desirable and the actual training in science that teachers receive.

In summary, then (1) the academic programs in colleges for training science teachers do not appear to be sufficiently extensive to enable the teachers to carry out their duties optimally; (2) state requirements in academic courses are not always sufficiently extensive to improve the situation; and (3) supervisory practices may need improvement. Thus, there is a good deal of evidence to indicate that many science teachers are not sufficiently well trained to carry out successfully the jobs they are doing and hence are not likely to inspire students to take more science.

Mathematics

The search for information concerning certification requirements for teachers of mathematics was made by writing the various state Superintendents of Public Instruction. One reply suggested that Dr. H. H. Irwin of the Department of Mathematics of the State College of Washington, Pullman, Washington, together with members of the Northwest Section of the Mathematical Association of America had previously carried out such an investigation. A communication from

[11] Pruitt, Clarence M., "Certification Requirements for Teachers in Elementary and Secondary Schools." *Science Education*, XXXVI (April 1952), 182–93.

Dr. Irwin revealed that the study was undertaken for "determining the mathematical training of teachers in secondary education, and State requirements for certification to teach the subject of mathematics in these schools."[12] The study consisted basically of four phases: 1. A questionnaire was sent to a large number of the Northwest Colleges "to determine whether or not the colleges and training schools of the Northwest were giving the proper sequence of courses which would train the teachers of secondary education for their jobs." 2. In order to determine the relative importance of the courses in the programs mentioned in (1) a questionnaire was submitted to the high-school teachers of mathematics in a number of the "first-class districts" in the Northwest and also to the college teachers of mathematics in that region for their appraisal of the courses. 3. On the same questionnaire were included other questions designed to reveal the extent of the mathematical training of the teachers who filled out the questionnaire. 4. A questionnaire "was submitted to the State Superintendents of every state. . . ."

The investigation revealed that (1) there is considerable variation among the training programs in the colleges of the Northwest, but even in the schools requiring the minimal number of courses, the training is considered sufficient to prepare well-rounded teachers of high-school mathematics; (2) there is close agreement among high-school teachers and college teachers as to the relative importance of the courses offered in the programs; (3) in general the teachers in the first-class districts seem to be well-trained in mathematics—most of them having a Bachelor of Arts Degree in Mathematics and many of them having a Master's Degree; and (4) many of the states require a minimum of eighteen hours or more of college training in the field before a teacher was allowed to teach mathematics in accredited schools. However, in two schools one or two instructors were teaching mathematics with little or no training in mathematics whatsoever, and in others the minimum was as few as three hours and in another group of states a teacher could teach a course in high-school mathematics without having had any college training in mathematics if the course were assigned to him by a principal. In the opinion of Dr. Irwin and his committee this was the most deplorable situation uncovered in the entire study.

The statistics obtained in the study were summarized and presented in form of a map. The information revealed by the map is found in Table VI on the following page.

According to the same committee "the conclusion was reached that the weakness as far as mathematics teaching in secondary schools in the country was concerned was the fact that State Boards of Educa-

[12] Letter dated October 26, 1951 from H. H. Irwin to Donald Worth.

TABLE VI. MATHEMATICS REQUIREMENTS FOR TEACHERS OF MATHEMATICS IN SECONDARY SCHOOLS

Semester Hours of Mathematics	Number of States Requiring
Above 18	13
15–18	15
Less than 15	13
No requirements	7

tion vary so greatly in their requirements for certification to teach."

Apparently the lack of subject-matter competence in teachers of mathematics is not so marked as in teachers of science. However, the conditions that obtain for certifying teachers of science also obtain for certifying teachers of mathematics. Hence, it can be stated defensibly that the evidence points strongly to the possibility that teachers of mathematics in general are not so well trained in mathematics as they might be. Certainly there is no evidence to assure one that all mathematics teachers have the desired competencies. In addition, it is well-known that in those states in which the requirements are established by local boards of education, as well as in many small school districts throughout the United States, the subject-matter backgrounds of teachers are frequently unsatisfactory. Hence in many localities, it is probable that there are many teachers whose backgrounds are not sufficient to enable them to inspire students to continue in the field of mathematics.

C: *What requirements in course work are established by state boards of education for graduation from high school?*

It is well known that the changing of the objectives of the high school from those of specialized education to general education, resulted in the increase in the number of required courses that are common to all curricula. Most of these common courses are "designed to train the student to participate more effectively in the society of which he is a member." In most cases such course requirements are established through the central agencies for education in the various states.

The members of this committee believed that it would be desirable to investigate the extent to which these agencies had set up course requirements for graduation from the secondary school, and to determine the place of courses of mathematics and science in these requirements. Letters were sent to the Superintendents of Public Instruction of all the forty-eight states requesting course requirements for graduation from high school. Forty-five of the forty-eight states responded. The replies are summarized in Table VII.

TABLE VII. STATES REPORTING REQUIREMENTS FOR HIGH-SCHOOL GRADUATION

Subject	Number	Percent
Mathematics	21	47
Science	21	47
English	31	69
Social Studies	32	71

The data in Table VII show clearly that, on a state level, greater emphasis is placed on English and social studies than on science and mathematics.

More significant, however, in showing the added emphasis placed by state departments of education on social studies and English are figures concerning the total number of credits required in various subject areas for high-school graduation. Table VIII shows these relationships.

TABLE VIII. A COMPARISON BY GRADES OF SUBJECT-MATTER REQUIREMENTS FOR HIGH-SCHOOL GRADUATION IN FORTY-FIVE STATES

Grade	Subject	Total Number States Reporting	Number of States Requiring Subject Continuously Through Grade Indicated	Percent of States Requiring Subject Continuously Through Grade Indicated
9	Mathematics	45	21	47
9	Science	45	21	47
9	English	45	31	69
9	Social Studies	45	32	71
10	Mathematics	45	2	4
10	Science	45	3	7
10	English	45	29	64
10	Social Studies	45	20	45
11	Mathematics	45	1	2
11	Science	45	0	0
11	English	45	28	62
11	Social Studies	45	7	16
12	Mathematics	45	0	0
12	Science	45	0	0
12	English	45	8	18
12	Social Studies	45	0	0

It is clear from these figures that most states require mathematics and science in the ninth grade. A large percentage require social studies through the tenth grade and a significant percentage, through

the eleventh. An even larger number of states have English requirements through the eleventh and twelfth grades.

Whether this unequal weighting of requirements is desirable is beyond the scope of this investigation. However, it would seem that in view of recent urgent requests by industry for mathematicians and scientists, a very good case could be made for an increased emphasis on requirements in mathematics and science education in our schools.

It is reasonable to assume from these data that state requirements which so clearly emphasize the field of English and social studies as opposed to mathematics and science may be a direct reflection of the attitudes of controlling agencies with respect to the relative values of different curriculum areas. It may also be reasonable to infer that teachers of mathematics and/or science have not been so insistent in their demands for raising graduation requirements in these fields as teachers in other subject-matter areas.

D: *What academic backgrounds do guidance counselors have that may motivate them to suggest that students take courses in science?*

Among the various considerations discussed by the committee was the role played by the high-school counselor in guiding students into certain courses. It has been generally assumed that the academic back grounds of guidance counselors are more likely to be in the area of social studies than in mathematics and/or science. Hence, it is logical to assume that where election of courses is permissible, the counselors are likely to advise students to elect courses in areas other than mathematics and science. It was therefore decided to investigate, in so far as possible, the academic backgrounds of a sampling of guidance counselors in the midwest.

Letters were sent to Superintendents of Public Instruction of Minnesota, Wisconsin, Iowa, Illinois, Indiana, Michigan and Ohio requesting the names of the guidance counselors in their respective states. Lists were received from all but one. From each of the lists received were chosen at random the names of approximately forty guidance counselors. To each of these counselors was sent a letter ex-

1. Approximate portion of working hours spent in guidance activities (please check):

   $\frac{1}{4}$_____ $\frac{1}{2}$_____ $\frac{3}{4}$_____ All_____

2. Undergraduate majors and minors (please state).

   Major_____ Minor_____

   Minor_____ Minor_____

3. Areas of specialization at graduate level (please state). Major area_____

   Minor area_____ Minor area_____

plaining the project. Enclosed was a return postcard requesting information concerning his academic background. Two hundred fifty cards were mailed out; one hundred forty-one were returned, of which one hundred thirty-nine contained usable material.

A sample of the card is shown on page 133.

Table IX that follows lists the approximate portion of working hours spent by the respondents in guidance activities.

TABLE IX. APPROXIMATE PORTION OF WORKING DAY DEVOTED TO COUNSELING

Portion of Time	Number Reporting
One-eighth	2
One-seventh	3
One-sixth	2
One-fifth	1
One-fourth	50
One-third	1
One-half	30
Three-fifths	1
Two-thirds	1
Three-fourths	17
All	31
Total	139

Table IX indicates that the vast majority of counselors are part-time workers that devote one-half or less of their time to guidance activities.

Table X lists the academic areas at the undergraduate and graduate levels in which the respondents had *majors*.

TABLE X. ACADEMIC MAJORS OF GUIDANCE COUNSELORS

Area and Subject Field	Number Reporting at Undergraduate Level	Number Reporting at Graduate Level
1. Business Administration	2	3
Business Education	2	1
2. Education	15	26
Administration	—	22
Audio-Visual Education	—	1
Community Recreation	1	—
Curriculum	—	2
Educational Psychology	—	6
Guidance	1	48
Physical Education	2	2
Special Education	1	—
Supervision	—	4

TABLE X—(*continued*)

Area and Subject Field	Number Reporting at Undergraduate Level	Number Reporting at Graduate Level
3. English	17	2
Speech	3	1
4. Industrial Arts	2	1
Vocational Education	—	1
5. Language		
French	1	—
Latin	1	—
Spanish	2	—
6. Mathematics	19	—
7. Psychology	3	1
Child Psychology	—	1
Clinical Psychology	—	2
8. Science		
Agriculture	1	—
Biology	2	1
Chemistry	4	—
Horticulture	1	—
Physics	2	—
Physiology	—	1
Science, general	5	—
9. Social Studies	19	4
Economics	3	2
History	23	5
Political Science	—	1
Social Work	—	1
Sociology	6	1
10. Miscellaneous		
Home Economics	4	—
Music	3	1
Philosophy	2	—
Retailing	1	—

Table X indicates that fewer counselors are trained in the fields of mathematics and science than in certain other fields. To illustrate, *sixty-five* of the respondents had undergraduate or graduate majors in the social studies field; ***nineteen*** had undergraduate or graduate majors in mathematics; only ***seventeen*** in science.

Table XI reveals that ***ninety-two*** of the respondents reported that they had minors in social studies either at undergraduate or graduate levels, *fifty-four* in science and only *twenty-one* in mathematics.

Table XI is the same as Table X except that it deals with *minors*.

TABLE XI. ACADEMIC MINORS OF GUIDANCE COUNSELORS

	Number Reporting at Undergraduate Level	Number Reporting at Graduate Level
1. Business Studies	4	1
Accounting	1	—
Commercial	—	1
2. Education	27	15
Administration	—	17
Curriculum	—	9
Educational Psychology	—	4
Guidance	4	—
Guidance (counseling)	—	21
Instruction	—	4
Outdoor Education	—	1
Physical Education	7	—
Special Education	1	—
Statistics	—	1
Supervision	—	3
Testing	—	1
3. English	32	8
Drama	—	1
Journalism	1	1
Speech	5	1
4. Industrial Arts	3	—
5. Language	6	—
French	9	1
German	7	—
Latin	3	—
Spanish	3	—
6. Mathematics	18	3
7. Psychology	9	14
Mental Hygiene	—	1
Social Psychology	—	1
8. Science	31	—
Agriculture	1	—
Biology	8	1
Chemistry	3	—
Earth Science	1	—
Physical Science	2	—
Physics	6	1
9. Social Studies	33	4
Economics	5	—
Geography	5	—

TABLE XI—(*continued*)

	Number Reporting at Undergraduate Level	Number Reporting at Graduate Level
Government	1	—
History	21	4
Human Relations	—	1
Political Science	5	1
Rural Sociology	—	1
Social Work	—	1
Sociology	4	6
10. Miscellaneous		
Art	—	1
Home Economics	3	—
Law	1	1
Library	1	2
Music	3	1
Philosophy	1	—

These facts in and of themselves do not indicate that guidance counselors are unsympathetic to mathematics or science. However, one can assume that if a student is doubtful as to which subject to elect, the suggestions given by the counselor are likely to be influenced by his background. The facts here indicate that such influence is less likely to be in the areas of mathematics and science than in some other areas.

State III: *Recommendations for Increasing Enrollments in Mathematics and Science.*

The interpretations and recommendations that follow have been made in the light of the evidence already given. Before such interpretations and recommendations are made however it is necessary to cite certain limitations:

1. The data that were obtained are not sufficient in all cases to warrant unqualified interpretations and conclusions.

2. The committee was unable to find any facts that could be construed without qualification as causation for the drops in enrollments. The facts that were obtained, singly or collectively, are possible, or are even probable, elements of causation, although the factor "beyond all reasonable doubt" is not always present.

3. Certain findings are interpreted in the light of data not directly related to, nor given in, this study.

* * *

In so far as the techniques used in this study may be valid the fol-

lowing interpretations, conclusions and recommendations seem defensible:

1. Beyond all reasonable doubt, in the last three decades enrollments at the high-school level in a number of the specialized courses in mathematics and science, have decreased in terms of percentages, and in a few cases in terms of numbers. On the other hand enrollments have increased both percentage-wise and numerically in the generalized courses, such as general mathematics, general science and general biology. Further, although not so clearly indicated in the data, enrollments in general physical science are steadily growing.

Without doubt, enrollments in general science have remained high because general science is a required course in many schools. It is clear also, that enrollments have grown in general mathematics. The chief reason is probably that in many schools this course is recognized as an option for meeting the requirement of one year of high-school mathematics. However, for the period covered in this study, general biology has shown a relatively steady growth in enrollment without benefit of the "required" label. Within the last five years a similar growth in enrollment has been evident in the course in general physical science.[13]

However, for the period covered in this study, enrollments in plane geometry, higher algebra, and physics, as well as in certain other more specialized courses in mathematics and science have generally shown varying degrees of decline. One reason for this may be that while the general courses have been labelled as desirable for all persons, the older connotation of "college-entrance" is still borne by these higher courses thus setting up limitations for enrollment. Further, many of the educators in mathematics and science regard the higher-level courses as part of a different educational sequence designed for a different purpose. The connotation of "tough" is too often attached to such sequences and thus the students avoid them.

The result of this situation is that a comparatively small percentage of students who take courses in high school science and mathematics ever receive any training in these fields beyond the tenth grade level. There is evidence that this is continuing to occur, in face of the urgent need for new recruits of high caliber for the already inadequate army of trained science and mathematics teachers and in the face of the unsupplied demand of our economic and industrial system for more and better trained scientific and technical personnel. Our present technology depends upon an ever increasing number of men and women well-trained in biology, chemistry, physics, mathematics, and engineering. The past year around 15,000 engineers graduated

---

[13] This course is generally taught at the tenth-grade level or above.

from colleges in the United States but the demand was actually double this number. According to a recent American Chemical Society report[14] only 5800 bachelor degrees were conferred in chemistry the past year. In order to meet the demands of a rapidly growing chemical industry, somewhere between nine to ten thousand graduates in chemistry are needed annually. To meet the challenge of our times, high school enrollments in higher level science and mathematics courses must not merely hold their own, percentage-wise, but must increase significantly.

With these facts in mind, the committee makes the following suggestions:

1. A major effort be exerted to modify the college-entrance approach frequently used in these higher-level courses and to organize them around materials that are within the experiences of students whether they be terminal or college-entrance. While considerable changes have been made, it is well-known that the approaches to many of the problems in higher courses in mathematics and many of the experiments in higher courses in science could profit from further modification. Many problems need to be brought up-to-date, and experiments need to be modified in terms of what educational psychology has shown to be desirable in terms of an inductive approach. This recommendation carries with it implications for much cooperative work on the part of scientists, mathematicians and educators.

2. A new view should be taken with respect to higher-level courses. It is becoming apparent that generalized courses in mathematics and science are here to stay. Every attempt should be made to show that the generalized courses offer a firm foundation from which the specialized courses are logical outgrowths. Educators in mathematics and science should attempt to gain "psychological ownership" of the idea that higher-level courses in mathematics and science, modified as already indicated may be logical electives for all students when taught on the basis of well-taught general education courses. If the more successful educators in mathematics and science firmly back the idea of generalized mathematics and science and help to build and teach such courses, probably many students who now find the higher courses difficult, will find them less difficult and will decide to elect them.

3. There needs to be more emphasis placed on activities that will motivate and interest students in mathematics and science. Apparently there is no "natural" interest in mathematics and science that flourishes as a person grows in his environment. The research reported herein indicates that interests tend to be transient and are

---

[14] Stanerson, B. R., "Graduates in Chemistry." *Chemical and Engineering News*, XXXI, (June 1953), 2376–2379.

likely to change unless positive efforts are taken to develop them.

4. Educators in mathematics and science at all levels may well devote time to participating in adult activities and organizations in which the values of mathematics and science can be publicized. In most of these activities and organizations, programs are concerned mainly with topics of social rather than scientific significance. Many more adult education projects are focussed on contemporary affairs than on problems of mathematical and scientific concern. There needs to be a greater attitude of "socialization" on the part of mathematicians and scientists and a greater willingness to participate in programs, activities and organizations in which the values of mathematics and science can be made clear to the lay public. If efforts are made to educate parents in the values of mathematics and science as indicated, the influence may radiate to the children.

5. In many schools there needs to be more emphasis on the place of the mathematics and science clubs as agencies of orientation rather than culmination. In many schools the mathematics or science club has become a means of rewarding and publicizing the achievements of those who have taken much mathematics or science rather than a means of interesting the general student in the possibilities of mathematics or science. With this in mind it is recommended that mathematics and science clubs be established for students at the junior-high-school level in order to stimulate latent interests in mathematics and science, If this is done, many students who ordinarily would not take higher-level courses may do so because positive efforts have been taken in this direction.

6. The training of teachers in mathematics and science needs improvement. It is well-known that most teachers will at one time or another devote a portion of the working day to teaching generalized courses. Such courses demand a breadth of training in various areas of mathematics and science which these teachers do not usually have. In the area of science, evidence indicates clearly that teachers who are broadly trained, and hence competent to teach generalized courses effectively are too few in number. The generalized courses are often assigned to teachers who have "open periods" and who have little or no training in science. Thus the student is introduced to science by those who have little interest or who are inadequately prepared. This problem seems related to the facts already revealed concerning the status of teacher certification. Unless more importance is attached to science teaching by professional educators, it is doubtful whether laymen are likely to regard it highly.

It is therefore recommended, despite the shortage of science teachers, that organizations interested in the training of teachers join forces in demanding that certification requirements allowing teachers to

have majors and minors in one area of science with little or no training in other areas be changed immediately. It is unrealistic to train teachers in combinations of subject matter that are not generally found in schools. Every effort should be made to see that science teachers should be trained both intensively and extensively in the areas of science taught in high school. This does not mean a total of five hours in each of the areas. It means a program of course work of sufficient breadth and depth to assure competence to teach a total science program. The content and formulation of such a program could well be a project for future study by the Central Association of Science and Mathematics Teachers.

In mathematics the matter is somewhat different. However a survey of the courses listed by H. H. Irwin[15] fails to show that any major effort is made to provide any integrated training in mathematics that will enable embryo teachers to teach general mathematics effectively. The following statement from a report prepared at George Peabody College for Teachers substantiates this view.

"It may be readily seen that addition of all which seems very desirable of the study of a teacher training program would be impractical from the standpoint of time required, nor is that proposed. Yet there needs to be a recognition that special training is needed for teaching general mathematics and a proper time allocation made for it. This will only be accomplished by a reevaluation of the programs for training high school mathematics teachers in consideration of the needs of teachers in general mathematics and in the sequential courses."[16]

Hence, it is recommended that departments of mathematics in higher institutions take steps to develop courses that will train these teachers suitably. There is no psychological evidence to support the assumption that if one is well-trained in the separate courses in college mathematics, the ability to simplify and integrate topics for general mathematics is a natural concomitant. In fact, there is a good deal of evidence to show that such an assumption is unwarranted.

The evidence shown concerning certification requirements indicates also that study needs to be made of what constitutes a desirable program of mathematics for training teachers. Once such a determination is made, efforts should be expended to have the certification requirements of states changed to be in accord with the findings.

The committee at this point would like to emphasize that the recommendations made so far will demand cooperative and concerted action on the part of all professional persons concerned with mathematics and science education. Such persons include scientists, educators, mathematicians and others specializing in the methodologies of mathematics and science education. Unfortunately, such cooperation is not always evident.

---

[15] See page 129 of this report.

[16] Letter from Edward H. Matthews dated June 29, 1953.

Recently, in certain journals there have appeared many articles that have castigated, and many that have defended, the teaching of mathematics and science in the public schools. The committee heartily commends the authors of such articles in which commendation is given to the strengths of programs of mathematics and science and in which *constructive criticism* is given the weaknesses. However, the committee unequivocally deplores the publication of articles in which the criticisms are destructive, in which biased opinions are expressed, and in which personalities rather than issues are discussed. Unfortunately, a number of recent articles, some prepared by academicians, and some by educators, have fallen in the latter category.

The committee recommends that the societies, whether academic or educational, to which the authors of such articles belong, make every attempt to discourage the publication of articles that tend to destroy the possibilities for cooperation that is so greatly needed.

7. There needs to be a reevaluation of requirements for graduation from high school. If a person were to examine carefully everything he could see about him, it would be difficult for him to identify an object or material that in some way had not been improved by the application of principles of mathematics and of biological and physical science. Thus, every citizen should have an awareness of the implications and uses of mathematics and science in everyday life. Unfortunately, requirements for graduation from high school in the various states do not seem to take cognizance of this implied importance.

Few persons would question the importance of four years of English in high school, or advocate the reduction of the number of required courses in social studies. However, it is difficult to justify the usual requirement of only one year of mathematics and only one year of science.

The committee believes that it is reasonable that every high-school student should be required to take a course in general biology, preferably at the ninth-grade level and a course in general physical science, preferably at the tenth-grade level. Present trends in the teaching of science seem to indicate that the allocations of general science to grades one through eight with general biology and general physical science placed in the ninth and tenth grades offers a splendid base program of value to all students and from which the specialized courses such as chemistry and physics may well be logical outgrowths.

In the area of mathematics it is recommended that some type of base program be required in the ninth and tenth grades. What these courses should consist of is still a matter of conjecture, since mathematical associations are not in agreement as to a single sequence; or to a double sequence, one general and one specialized.

However since the adult will make use of various mathematical

skills throughout his entire life, and the absence of such skills in adults is frequently all too obvious it is believed that two years of mathematics in the ninth and tenth grades should be established as a requirement for graduation from high school.

If such a program is established then the public will have increased faith in the value of mathematics and science. The value of this is obvious, since it is usually the public that controls education at the local and state level.

It is likely that overall interest of the public in mathematics and science will eventually result in increases in enrollments. However influencing guidance counselors who are not necessarily trained in mathematics and science is not so easy a task. At times mathematicians and scientists have regarded the guidance process rather lightly, and sometimes the guidance counselors have dismissed the higher courses in mathematics and science as being somewhat meaningless to most students.

The committee therefore recommends that mathematicians and scientists cooperate with professional educators in taking a realistic view of the scientific nature of certain aspects of the guidance process. Unfortunately, in many schools guidance programs have consisted chiefly of the administering of tests of dubious validity and the giving of therapeutic advice by persons who are inadequately trained. Teachers of mathematics and science should take interest in helping to develop a guidance program that takes cognizance of the scientific analysis of personality, the mathematical bases for test construction, the biological bases for human behavior and the scientific integration of evidence obtained from tests. It would be desirable for mathematicians and scientists to cooperate in establishing requirements for guidance personnel whose functions cut across all subject-matter fields. Further, it is desirable for mathematical and scientific organizations to develop programs for emphasizing the need of persons trained in mathematics and science to enter the guidance profession.

It may be that some persons will be disappointed with the tenor of the report. Perhaps it was thought that ground work would be laid for a vast publicity program that would stimulate a universal interest in the significance of mathematics and science in education. Such might have been inspiring, but it would have been equally platitudinous and unrealistic.

A sober analysis, which the committee hopes that it has made, indicates that we have much hard work to accomplish to "get our house in order." The committee therefore recommends that the Central Association of Science and Mathematics teachers undertake a serious and planned attack on the major problems revealed in this report.

A SCIENCE ANNUAL FOR HIGH SCHOOL STUDENTS

LOUIS PANUSH

Northeastern High School, Detroit, Michigan

In the fall of 1937, as a result of insistent requests by a number of physics and chemistry students, a Science Club was reorganized and reactivated at Central High School, Detroit, Michigan, under the sponsorship of the author, who in 1936 permanently joined the faculty of the school. For a number of years thereafter, the school's outstanding science students showed unparalleled enthusiasm in the programs and activities of their club which, during the years of its existence, played a dominant role in the science and extracurricular activities of the school.

This is a brief report on one phase of the Science Club's varied activities, *The X-Ray*, a science annual for high school students, which was originated, sponsored and maintained by the author from 1938 through 1944.*

Even during the first year of the Science Club's organization, students began to feel the need of a publication which would record the club's programs and activities and familiarize the student body and the faculty with the aims and achievements of one of the successfully functioning school clubs. It was also felt that, since the school had no other publication outside of the school paper and a non-literary senior annual, there was a need for a "journal" which would offer students an opportunity to develop their literary and journalistic talents—via science. In addition, the sponsor and the science faculty felt that such a publication would serve to publicize the science department and its activities and recruit students for its science courses.

The first issue of *The X-Ray*, published in June 1938, was a mimeographed bulletin of some 25 pages. It had an attractive hard-paper cover, with a mimeographed design of an X-ray tube (done by one of its members, now a teacher in the same school), and its stencils were cut and run off on the machine by the club members. About 350 copies of this issue, at 10 cents per copy, were sold out a few days after publication. The major part of the bulletin was devoted to the "Fight Cancer" campaign project, which was the main activity of the Science Club during that semester. The rest of the bulletin contained articles on scientific subjects, student and faculty opinion on the aims and activities of the club, organizational material, the beginning of a

* In January 1943, the author assumed the editorship and business management of the *Metropolitan Detroit Science Review*, then a mimeographed bulletin, and converted it into a printed science education journal in 1944. Much to his regret he had to give up both the sponsorship of the Science Club and *The X-Ray*.

series on the vocational and professional aspects of science, and a contribution by an alumnus on "The Autobiography of a Calorie." *The X-Ray* was acclaimed by students, faculty and parents.

It was planned, at first, to have a semi-annual publication. Therefore, the second issue was published at the end of the next semester, January 1939. This one was a much more impressive publication, done commercially by a multigraphing company. It was organized, and its contents were much along the same line as the first issue. A few new sections were added: "Can You Believe It" column, Book Reviews, etc. Over 1,000 copies were sold out, at 10 cents per copy. Since the theme of the Science Club for that semester was to attract students to the various science courses offered in the school, the bulletin was primarily devoted to that project. It published the winning essay in a scientific essay contest which was sponsored by the club, in addition to other articles of scientific nature and content.

As a result of the school's enthusiastic acceptance of *The X-Ray*, it was decided to publish it as an attractively printed and illustrated journal. Since this involved a considerable expense, and the principal's consent was obtained only after he was assured that the journal would be self-supporting and would not solicit any advertising (in order not to compete with and cut in on the revenues of the school paper and the senior annual), it was decided to publish the journal as an annual with a "must" circulation of 1500 to 2000. Beginning with the June 1939 issue, all annuals were 52-page booklets, printed on fine glossy paper, enclosed in attractive hard-paper covers, and whose contents were of great interest and worthwhileness to all high school students. It is interesting to note that the 1939 and 1940 booklets were sold at 10 cents per copy, the next two at 15 cents per copy, and the 1944 issue at 25 cents. At no time was there a deficit. The journal was not only self-supporting; rather, it supplied the club's treasury with substantial surpluses which enabled it to finance other money-consuming activities.

The success of *The X-Ray* was due primarily to the enthusiasm and efforts of its editorial and business staffs, to the devotion of the club's members and to the wholehearted cooperation of the faculty and student body. It was an extracurricular activity. Research on articles and all business matters were done during vacant periods and after school. Advance selling, concentrated in a short period in record groups, study halls and science classes, made it possible to plan carefully the financing of the magazine. Of great help were the engravings which business, industry and scientific journals lent for use without cost.

The X-Ray was published once more in 1945 under the sponsorship

of another member of the science department. It was the last issue of this fine student publication at Central. Its discontinuation was a great loss to the students, the science department, and the school.

This brief report on a student project which was carried out years ago is presented in the belief that this activity can and should be duplicated by other active science clubs under the sponsorship of an interested science department. It is an unusually good, stimulating and worthwhile activity "which induces continuing interest and activity in the study of science."

The following are some of the values which may be derived from publishing a science journal by and for high school students:

1. The publication will serve as a continuous and permanent record of the science club(s) and the science department, a record which is of great interest to students, faculty, and administration.

2. It will stimulate lively student interest in scientific activity outside of classroom study and textbook material.

3. It will provide opportunity for creative work for those who may be slow at individual experimentation and projects promoted by the club(s) as well as those who express themselves in writing, editing, managing, selling, and other activities connected with a publication.

4. It will send interested students to magazines, newspapers, scientific journals, research centers, industries, etc. to learn about and report on the newest advances in the various fields of science in which their interests lie.

5. A good publication, attractively printed, readable, interesting and illustrated will be read from cover to cover. It will bring science to many students for whom biology, in the tenth grade, is otherwise probably the terminal course in science in their high school career. It will encourage many students to elect one or more of the other science courses offered in their school. The increase in the number of science classes and in student enrollments in these classes at Central High School, in both college preparatory and non-academic courses, was in no small measure due to the popularity and influence of *The X-Ray*.

6. It will encourage good reading, generally, and the reading of scientific material, in particular, on the part of club members who participate in this activity *and* on the part of other readers as well. Science books reviewed in the journal will become popular with students.

7. The record shows that many of the students who did their first research and reporting on a certain scientific subject or in a special area of science have been sufficiently stimulated to select that area for a career in science. From the ranks of *The X-Ray's* staffs, over the years, have come doctors, chemists, engineers, physicists, biologists,

geologists, science teachers, university teachers, lawyers, nurses, technicians, and so on. Many of them credit the Science Club and its publication with starting them on the road to their scientific career; most of them remember their club activities and their work on the Journal as some of the finest and the most satisfying experience of their high school life.

8. And last, but not least, it will provide one form of direct experiences in science and crown incentive, ability and achievement with recognition by and appreciation of fellow students and teachers.

THE USE OF LARGE SCALE CALCULATORS

FRED GRUENBERGER
Numerical Analysis Laboratory, University of Wisconsin, Madison, Wis.

Although high school students display tremendous interest in automatic calculators (particularly electronic calculators) and are surprisingly well informed about them, they usually labor under two gross misconceptions:

(1) the machines can think;

(2) since they have been told that some machines work thousands of times faster than human beings, they wonder why our problems are not solved immediately and, in particular, why the machines don't run themselves out of work.

The first misconception is unfortunate and due in large part to the Sunday supplement articles which continually refer to the machines as "brains." It would be quite proper to refer to such machines as giant electronic morons. For one thing, all machines so far built or planned are capable of just four operations: addition, subtraction, multiplication, and division. All other functions are built up from sequences of the basic four. While it is possible for a machine to make a logical choice between two or more possible avenues of calculation, the choice is made usually by comparing by subtraction, together with a test to determine whether the result is positive, negative, or zero.

In the second place, the machine does only what its human operator directs it to do, and if the directions are incorrect the machine will faithfully carry out the incorrect orders. A machine cannot be expected to judge whether the results it gets are reasonable unless an arithmetic test of reasonableness is specifically programmed. If the operator has overlooked simple and obvious shortcuts (which he himself would use when doing the same calculations on paper), the machine will continue to follow its instructions the long way around.

In the final analysis, machines which are popularly given the ability to think are not smart enough to turn themselves on in the morning.

The second misconception is a logical one and bothers even people who are quite familiar with small calculators. The answer is simple and follows two paths:

(1) Problems tend to grow with the machines. Those problems which we can now do readily on small machines are pushing the machines to the limit; as the machines get bigger and faster the same problems are extended to the limit of the new machines. For example, a common problem in any computation laboratory is that of producing a matrix of correlations. With equipment no greater than desk calculators and perhaps a mechanical automatic machine (e.g., an IBM 602A) the problem is limited to a few variables, say 20. When a small electronic machine is available, it becomes feasible to handle perhaps 60 variables. A large scale, high speed machine allows the problem to run to hundreds of variables. This, of course, is oversimplifying the situation, but the principle is correct.

(2) The world is full of problems which are simple to understand but which stagger the greatest machines yet built. Three examples are given.

The determination of prime numbers now demands larger and faster machines. All primes are known up to about 30,000,000. The largest machines now in existence can find all the primes in a million successive digits in a few hours, in a range less than, say, 50,000,000. But as we proceed out in the number system, the problem gets progressively harder. If it becomes worthwhile to sift primes beyond 100,000,000, it will require machines much faster than those now available.

There is a very simple problem, of great practical importance, which has not even been attempted as yet. Suppose we have a group of 1000 persons and 100 of them have been selected at random as an experimental group for a study. We wish to find another 100 from the 900 available, to use as a control group, and have them matched as well as possible to the experimental group. The phrase "as well as possible" might imply that the match should be the best possible on the basis of sex, IQ, age, and scholastic standing. This in turn implies that each of the original 100 should be compared (perhaps many times) with each of the remaining 900 by a least squares technique to determine the best possible selection.

There is an even simpler problem which would challenge the best of our present day equipment. Consider all the prime numbers up to 500,000. Suppose we print next to them the successive differences. Thus, next to the first few primes suppose we have

2	
3	1
5	2
7	2
11	4
13	2
17	4
19	2
23	4
29	6.

In compiling this list, the following sequences are noticed:

391373		348437	
391379	6	348443	6
391387	8	348451	8
391393	6	348457	6
391397	4	348461	4
391399	2	348463	2

the list of differences being identical. The problem, now, is this: in the entire table, what is the longest such sequence which repeats? The table contains some 40,000 entries, which means that to find a set of six differences which repeat, it would be necessary to compare every set of six with every other set of six. The problem increases rapidly in complexity as the table of primes is lengthened. To find the longest repeating sequence of differences among all the primes now known would be a problem beyond the capacity of all the machines now in operation.

OKLAHOMA U. MATH LETTER APPLE PROBLEM

Three men find a pile of apples.

(1) The first man throws away one rotten apple and takes one-third of the remaining apples for himself.

(2) The second man now throws away one rotten apple and takes one-third of the remaining apples for himself.

(3) The third man throws away one rotten apple and takes one-third of the remaining pile for himself.

(4) All three men now approach the remaining pile together. Each man removes and discards one more rotten apple. Then each man takes one-third of the remaining pile of apples.

There are no apples left and no apples have been cut or broken in any of the steps (1) to (4) above. Find the smallest possible number of apples in the original pile.

Typewriter bail is made of a transparent plastic which permits the typist to see the typewritten line usually obscured by the common metal bail. It is available for all standard machines and can be installed quickly.

CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS

REPORT OF THE NOVEMBER 26–28, 1953 CHICAGO CONVENTION

Appreciation: The Board of Directors formally recognized the high excellence of the work of the team that designed and executed the plans for the 1953 Chicago Convention in a resolution accepting these plans with high commendation and gratitude from Mr. W. E. Jones, General Coordinator.

The Association recognizes herewith its indebtedness to the following and through them to their committeemen: Edgar S. Leach, C. W. Bills, Ethel M. Evans, Kenneth Hunt, Arleigh R. Hough, Donald W. Iverson, and Robert Smith.

Locale: The place of the convention meetings was the Congress Hotel in Chicago, Illinois.

Summary of Official Meetings

I. The Board of Directors Meeting Thursday, November 26, 1953, 3:30 P.M., Lake Shore Room

This was an executive meeting of the Board of Directors.

II. The Board of Directors Meeting Thursday, November 26, 1953, 7:30 P.M., Lake Shore Room

President Lauby discussed the Association's affairs. Reported ill and unable to attend this convention were Director Winnafred Shepard and Policy and Resolutions Committee Chairman Martha E. Curtis. The committee (Peak, Pella, and Price, Chairman) report on consolidating, coordinating, and increasing the efficiency and effectiveness of the Board appointed offices was considered and accepted.

Oral reports on the Journal's editorial problems and affairs and on the activities of the A.A.A.S. Cooperative Committee were given by Glen W. Warner and Donald W. Lentz respectively.

Written reports were accepted and filed for record and reference with the Secretary from the following officers and/or committees: Treasurer and Business Manager Ray C. Soliday (Nov. 18, 1953 audit and analysis report), Journal Chairman, Louis Panush, Local Arrangements, Chairman, W. E. Jones, Membership, Chairman, Harold Haggard, Yearbook Editor, Luther Shetler, and Convention Policies, John S. Richardson.

Elected to Emeritus Membership in the Association were

Mary A. Bennett
Agnes MacNeish
E. Lawrence Palmer
Hanor A. Webb
Stella N. Cathcart

There springs instantly into the minds of the many that have been privileged to know these teachers these words of estimation recorded in Isaiah, "Thou shalt also be a crown of glory in the hand of the Lord, and a royal diadem in the hand of thy God."

III. The Annual Business Meeting, Saturday, November 28, 1953, 10:30 A.M., Gold Room

The recommendation to hold the 1955 Annual Convention in Detroit, Michigan, was adopted.

The resignation of John S. Richardson from the Board of Directors was received. The necessity for Dr. Richardson to be relieved from some of the many demands upon his time and energy were reluctantly recognized, and his resignation referred to the Nominating Committee

The recommendations of the Nominating Committee were unanimously approved and the following declared elected as stated:

H. Vernon Price, President, 1953–1954
Milton O. Pella, Vice President, 1953–1954
James H. Otto, Director through 1955, and to replace John S. Richardson, resigned
Jacqueline Buck, Director through 1956
W. H. Edwards, Director through 1956
Louis Panush, Director through 1956
Reino Takala, Director through 1956

IV. The Board of Directors Meeting Saturday, November 28, 1953, 1:00 P.M., Music Room

Committee reports were received and placed in the records from these committees: Journal, Policy and Resolutions, and Membership.

The following three year tenure appointments, were made:

Treasurer and Business Manager, Ray C. Soliday
Secretary and Historian, Virginia Terhune
Editor, Glen W. Warner
A.A.A.S. Cooperative Committee Representative, W. H. Edwards

President Price was directed to appoint a committee to study and to make recommendations to the Board at the 1954 Spring Meeting of the Board of Directors changes in the By-Laws.

PROGRAMS

Details of the programs may be had from the 1953 Yearbooks that have been supplied to the membership.

SECTIONS OFFICERS FOR 1954

Biology: Chairman, James H. Otto; Vice Chairman, Robert Smith; Secretary, Hubert L. Edquist.

Chemistry: Chairman, Robert C. Grubbs; Vice Chairman, Louis Panush; Secretary, Allen Baker.

Elementary Mathematics: Chairman, Herschel Grime; Vice Chairman, F. Lynwood Wren; Secretary, Clarence Ethel Hardgrove.

Elementary Science: Chairman, Louis Rzepka; Vice Chairman, Sister Mary Evarista; Secretary, Emile Lepthien.

General Science: Chairman, Marjorie Barnes; Vice Chairman, John D. Woolever; Secretary, Nancy Ritter.

Geography: General Chairman, Laura Louise Watkins.

Mathematics: Chairman, Reino M. Takala; Vice Chairman, Dwain E. Small; Secretary, Luther Shelter.

Physics: Chairman, G. A. Waldorf; Vice Chairman, Bastian Fagginger-Auer; Secretary, Edwin Vaughn.

Respectfully submitted,
W. H. EDWARDS, *Secretary*

NEW WESTINGHOUSE ATOMIC PLANT

Engineering and other office personnel are moving into a new plant of the Westinghouse atomic equipment department. Located in Harmar Township approximately one mile northeast of the Allegheny Valley Interchange of the Pennsylvania Turnpike, the plant is part of the Westinghouse Atomic Power Division which is building the atomic submarine engine for the U.S.S. *Nautilus* and is developing the first civilian atomic power plant. This new plant will produce component parts and accessories for atomic power plants and represents initially a two million dollar investment by Westinghouse Electric Corporation.

INSTRUCTIONAL MATERIALS FOR NATURE STUDY

SAM S. BLANC
East High School, Denver 6, Colorado

Nature study is an area in which much pupil activity is possible. Probably the best means of studying plants and animals in their native habitats is by means of field trips. If a museum of natural history is within a reasonable distance from the school, the study of nature exhibits makes visits to the museum worthwhile learning activities. Pupils will certainly be interested in collecting leaves, flowers, and other specimens at the proper times of the year and arranging these in their own exhibits in the classroom. Many pictorial materials are at hand to teach this topic, and more slides are available in this area than in any other in the study of biological sciences. Pupils may be interested in making diagrams to represent natural habitats of groups of mammals, birds, reptiles, and so on, or to show wild flowers, plants, or other types of plant and animal associations.

The matter of distinguishing the poisonous snakes held a very high interest in the minds of pupils at this level. An excellent motion picture to use in this connection is *Snakes* (COR), one reel, in black and white or color. It tries to overcome the idea that all snakes are dangerous by presenting and distinguishing the four dangerous snakes found in this country. It helps pupils see how the dangerous varieties of snakes may be told from the harmless ones. Two filmstrips, *Lizards*, *Snakes*, *Turtles* (SVE), fifty frames, and *Reptiles of North America* (SF), thirty-two frames, are also available to develop an understanding on this topic.

The topic of bird study has so many motion pictures available that a complete listing of titles is hardly feasible. Instead, a general description of the number of films and the producers will be presented. If the teacher is interested in the specific titles, a catalog of that producers' products should be consulted.

1. Arthur Barr Productions—three, one-reel, black and white films
2. Almanac Films—five, one-reel, black and white films
3. Coronet Films—seven, one-reel, black and white films
4. Encyclopaedia Britannica Films—five, one-reel, black and white films
5. Heidenkamp Nature Productions—five one-reel, color films

Animals and pets, as a topic, may be treated in much the same way as the topic of birds. Many pictorial materials, slides and motion pictures are available. The following list of motion pictures is suggested:

1. *Beaver*	1 reel, b & w, EBF
2. *Common Animals of the Woods*	1 reel, b & w, EBF
3. *Cony*	1 reel, b & w, ABP

4. *Kangaroo Rat*	1 reel, b & w, ABP
5. *Mammals of the Countryside*	1 reel, b & w or color COR
6. *Mammals of the Rocky Mountains*	1 reel, b & w or color COR
7. *Mammals of the Western Plains*	1 reel, b & w or color COR
8. *Wild Animals, their Homes and Habits*	1 reel, b & w, ABP

Several filmstrips deal with the topic of animals also. In addition, pupils may be interested in particular aspects of protective coloration and other activities of the animals they study. The following list suggests a number of titles:

1. *Beaver*	30 frames, b & w, SF
2. *How Animals are Protected from their Enemies*	30 frames, b & w, SVE
3. *How Animals Get Air*	50 frames, b & w, SVE
4. *How Animals Protect Themselves*	30 frames, b & w, SVE
5. *How Color Protects Animals*	48 frames, b & w, SVE
6. *Some Squirrels and Other Gnawing Animals*	29 frames, b & w, SVE
7. *Wild Animals of the U.S.A.*	four parts, b & w, SF

The topics of trees, shrubs, and flowers are also amply illustrated by many pictorial materials. Interesting bulletin board displays, coinciding with the change in seasons, may help to keep interest in these topics current, and a one-reel motion picture in color, *Seasonal Changes in Trees* (COR), may be useful. A number of 2″×2″ slides are available to help pupils see these plants. It does not seem necessary for a study of this topic to include motion pictures. This topic does not involve motion, hence, the need for many motion pictures can not be seen. A number of excellent filmstrips are available, and the following titles are suggested:

1. *Spring Wild Flowers of the Open Field*	50 frames, b & w, SVE
2. *Spring Wild Flowers of Canyons and Woodlands*	50 frames, b & w, SVE
3. *Summer Wild Flowers*	50 frames, b & w, SVE
4. *Trees of Valleys and Foothills*	50 frames, b & w, SVE

The interest of junior high school pupils in animals was also on a very general level. Many pictorial materials may be found to develop interesting bulletin board displays. Some pupils may be interested in making charts and diagrams to illustrate such topics as protective coloration, food getting, or special adaptations. A number of 2″×2″ slides in black and white and in color are available from various sources. Field trips to zoos to study animal adaptations and protective coloration may be arranged. Many zoological gardens make an attempt to exhibit the animals in simulated natural surroundings. Pupils may actually see in situations such as these how the animals are adapted to meet natural conditions.

A wide variety of motion pictures and filmstrips are available by means of which the teacher may show the pupils the adaptations and protective features in animals. Two one-reel motion pictures in color, *Camouflage in Nature through Form and Color Matching* (COR), and

Camouflage in Nature through Pattern Matching (COR), are excellent to introduce the pupils to this concept. A new series of six color filmstrips, *How Animals Get their Food* (CF), takes up the adaptations for food-getting among mammals, birds, reptiles, amphibians, fish, and insects. Other motion pictures and filmstrips which are related to these topics are as follows:

1. *How Animals Eat*	1 reel, b & w, YAF
2. *How Animals Move*	1 reel, b & w, YAF
3. *How Animals Defend Themselves*	1 reel, b & w, YAF
4. *How Animals are Protected*	30 frames, b & w, SVE
5. *How Animals Get Air*	50 frames, b & W, SVE
6. *How Animals Protect Themselves*	50 frames, b & w, SVE
7. *How Color Protects Animals*	48 frames, b & w, SVE
8. *How Nature Protects Animals*	1 reel, b & w, EBF
9. *Life in an Aquarium*	1 reel, b & w, YAF
10. *Nothing Can Live Without Water*	50 frames, color, PSP

Laboratory dissections, although interesting to some pupils, are difficult to perform for this level. This type of study is probably more suited to detailed courses on the high school level. However, the circulation of blood through the external gills of a tadpole is easily demonstrated. A hole is drilled in a block of wood the size of the opening in the stage of the microprojector. A tadpole is wrapped in a moist cloth, and the gills are pinned so that they are over the opening in the block of wood. The body of the animal may have to be tied down so that it remains quiet during observations. The capillaries and the blood corpuscles circulating through them may be clearly seen. A one-reel motion picture, *The Heart* (ALF), is excellent in this connection since it illustrates the differences in the heart and the circulation between cold and warm-blooded animals.

SOURCES OF MOTION PICTURES AND FILMSTRIPS

ABP Arthur Barr Productions, 6211 Arroyo Glen. Los Angeles, Calif.
ALF Almanac Films, 516 Fifth Ave., New York, N.Y.
CF Curriculum Films, 10 E. 40th St., New York, N.Y.
COR Coronet Films, 65 East South Water St., Chicago, Ill.
EB Encyclopaedia Britannica Films, 1150 Wilmette Ave., Wilmette, Ill.
HNP Heidenkamp Nature Pictures, 538 Glenn Arden Drive., Pittsburgh, Pa.
PSP Popular Science Publishing Co., A-V Division, 353 Fourth Ave., New York, N.Y.
SF Stillfilm Incorporated, 171 S. Los Robles Ave., Pasadena, Calif.
SVE Society for Visual Education, 1345 W. Diversey Pkwy., Chicago, Ill.
YAF Young America Films, 18 E. 41st St., New York, N.Y.

Aluminum sheeting, rods, bars, angles and tubing now are available for the home craftsman and can be sawed, planed or drilled with ordinary woodworking tools. The aluminum comes in a variety of shapes and finishes and can be made into storm windows as well as ashtrays, dishes and candle holders.

A NEW INSTALMENT BUYING INTEREST FORMULA

LEE EMERSON BOYER
State Teachers College, Millersville, Pa.

With more and more attention being given to mathematics for general education purposes the topic of simple short-term instalment buying has assumed considerable prominence in curricula for colleges and high schools. Since the arithmetic solution for finding the annual rate of interest in these problems is cumbersome the topic presents an unusual educational opportunity for using certain algebraic concepts and techniques.

Quite a number of formulas have been developed for this purpose starting from different assumptions and on different levels of difficulty. This fact in itself makes the topic a good one for general education classes in that the difficulty of treatment can be adjusted to the students' backgrounds in mathematics. If desired, the topic can even be used to bridge the gap between arithmetic and algebra.

This note confines itself to the consideration of a simple new interest-at-end formula that has two advantages over some formulas now in use. The advantages are: (1) The last payment need not be equal to the preceding ones and (2) The formula holds even if the "interest" is greater than the regular periodic payments. Both of these advantages are necessary to handle many of the instalment problems suggested by current newspaper advertisements and mail order catalogues.

The development[1] of this new formula is best shown by considering the short problem: Cash price of article, \$65.00; down payment, \$15.00; carrying charge, \$3.00; amount of regular monthly payment, \$12.00.

Solution: During the 1st, 2nd, 3rd, 4th and 5th months the debts, from the consumer's point of view, are \$50.00, \$38.00, \$26.00, \$14.00 and \$2.00 respectively. These numbers can be rewritten as follows:

$$\begin{aligned} 50 &= 50 \\ 38 &= 50-(1\times 12) \\ 26 &= 50-(2\times 12) \\ 14 &= 50-(3\times 12) \\ 2 &= 50-(4\times 12) \\ \hline 130 &= 50\times 5-(1+2+\cdots+4)12 \end{aligned}$$

If we let B = unpaid balance at the beginning of the credit period

and m = amount of each regular payment, it is seen, using the formula for the sum of an arithmetic progression for the expression $(1+2+\cdots+4)$, that the total principal in effect for one payment period is

$$B(q+1)-\frac{q}{2}(1+q)m,$$

where q is the integral part of the quotient found by dividing B by m. Substituting this expression, simplified to

$$\frac{(2B-mq)(q+1)}{2},$$

in the simple interest formula $i=prt$, we obtain

$$r=\frac{2it}{(2B-mq)(q+1)}$$

where i = interest (cost of the loan) and t = number of payment periods per year.

For this problem,

$$r=\frac{2\cdot 3\cdot 12}{(2\cdot 50-12\cdot 4)(4+1)}=\frac{\cancel{72}^{\,18}}{\cancel{52}\cdot 5}=\frac{18}{65}=29\%.$$
$$13$$

Some people may prefer to add the carrying charge of \$3.00 to the difference between the cash price and the down payment. In that case the \$50.00 would be replaced by \$53.00. The formula would apply as before except that $B=53$ and $r=25\%$.

[1] The writer, in his mathematics classes for general education, much prefers to *develop* a simple formula that yields a result a little different from the compound interest rate but wholly exact in the light of the beginning assumptions and comprehended by the students than to *use* a formula whose derivation is beyond the students' understanding even if its use produces a rate closer to the compound interest rate.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON

State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the ones submitted in the best form will be used.

Late Solutions

2354, 5, 7; 2365, 6, 7. *V. S. Narayanan, Pudukkottai, India.*

2357. *John Jones, Jr. Hattiesburg, Miss.*

2372. *Robert Goldman, Far Rockaway, N. Y.; W. R. Warne, Mt. Pleasant, Ia.*

2370, 2, 5. *Richard H. Bates, Midford, N. Y.*

2372, 3. *Walter T. Grant, Rutherford, N. J.*

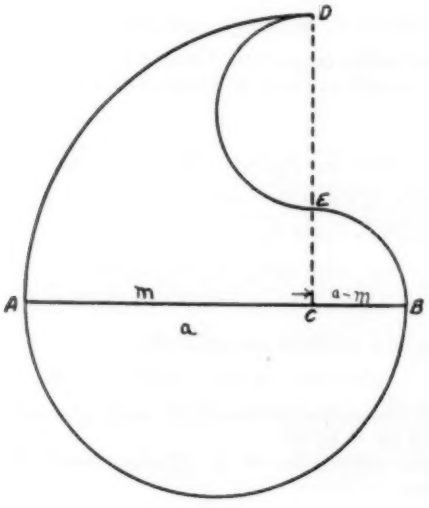
2365, 7. *Robert G. Comley, Dunmore, Pa.*

2377. *Proposed by Leon Bankoff, Los Angeles.*

C is a point on AB, with $AC>CB$. With C as center quadrants BE and AD are described on the same side of AB. D and E are joined by semi-circles forming a cusp at D and a flex point at E. Show that the area enclosed by the Figure $ABEDA$ is equal to that of the semi-circle on AB.

Solution by Herta T. Freitag, Hollins College, Va.

The area K, enclosed by the Figure $ABEDA$, is composed of the area of



quadrant ACD plus the area of quadrant ECB diminished by the area of the semi-circle on DE as diameter. Let $AB=a$ and $AC=m$, then

$$K=\frac{m^2\pi}{4}+\frac{(a-m)^2\pi}{4}-\frac{(2m-a)^2\pi}{8}.$$

This simplifies to

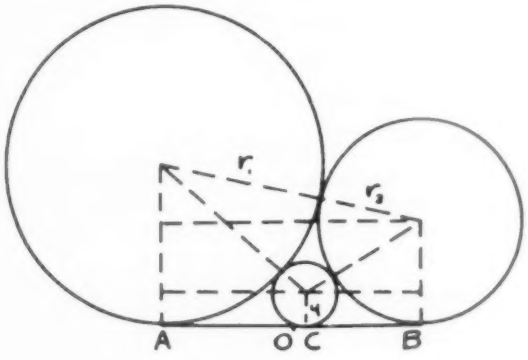
$$K=\frac{a^2\pi}{8},$$

the area of the semi-circle on AB.

Solutions were also offered by: Walter T. Grant, Rutherford, N. J.; Richard H. Bates, Milford, N. Y.; W. J. Cherry, North Riverside, Ill.; C. W. Trigg, Los Angeles City College; W. G. Koellner, N. J.; R. L. Moenter, Fremont, Nebr.; A. R. Haynes, Tacoma, Wash.; James F. Gray, San Antonio; Norma Sleight, Winnetka, Ill.; Lester Moskowitz, Brooklyn.

2378. *Proposed by Leon Bankoff, Los Angeles, Calif.*

AB is the common external tangent of two externally tangent circles. If AB remains fixed while the tangent circles vary, what is the locus of the center of the circle that is tangent to the two circles and to AB?



Solution by C. W. Trigg, Los Angeles City College.

Let the radii of the circles tangent to AB at A and B, be γ_1 and γ_2, respectively, and let the third circle with radius μ be tangent to AB at C. Let the center of AB be the origin. Then

$$AB=k=\sqrt{(r_1+r_2)^2-(r_1-r_2)^2}=2\sqrt{r_1r_2}, \quad \text{so} \quad \sqrt{r_2}=k/2\sqrt{r_1}.$$
$$AC=x+k/2=\sqrt{(r_1+y)^2-(r_1-y)^2}=2\sqrt{r_1y}, \quad \text{so} \quad \sqrt{r_1}=(x+k/2)/2\sqrt{y}.$$
$$CB=\sqrt{(r_2+y)^2-(r_2-y)^2}=2\sqrt{r_2y}.$$

Now

$$AC+CB=AB, \quad \text{so} \quad 2\sqrt{r_1y}+2\sqrt{r_2y}=2\sqrt{r_1r_2}.$$

Eliminating γ_1 and γ_2, we have immediately

$$x^2=-2ky+k^2/4=-4(k/2)(y-k/8).$$

Thus the locus of the center of the third circle is a parabola with vertex at $(0,\ k/8)$ and focus at $(0,\ -3k/8)$.

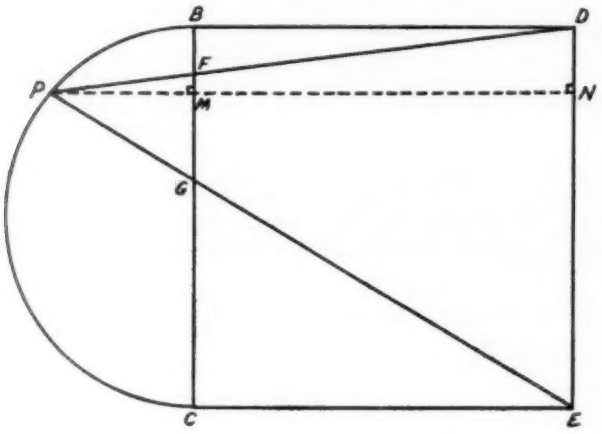
Solutions were also offered by W. J. Cherry, North Riverside, Ill.; Lester Moskowitz, Brooklyn.

2379. *Proposed by Leon Bankhead, Los Angeles.*

P is any point on semi-circle described externally on side BC of square $BDEC$. PD and PE cut BC in F and G respectively. Show that $BF \cdot GC = FG^2$.

Solution by Walter T. Grant, Rutherford, N. J.

Draw PN perpendicular to ED cutting BC at M.



Now PM is perpendicular to BC and we have

$$\triangle PDN \sim \triangle BDF \tag{1}$$

and

$$\triangle PNE \sim \triangle GEC \tag{2}$$

and

$$\triangle PFG \sim \triangle PDE. \tag{3}$$

By (1) we have

$$PN : BD = DN : BF.$$

By (2) we have

$$PN : EC = NE : GC.$$

By (3) we have

$$PN : DE = PM : FG.$$

But BD, EC, and DE are equal since they are the sides of a square Hence

$$DN : BF = NE : GC = PM : FG.$$

Now

$$DN = BM \quad \text{and} \quad NE = MC.$$

Hence

$$BM : BF = MC : GC = PM : FG. \tag{4}$$

Solve for FG in the last two ratios of (4) and then square both sides. Obtaining

$$FG^2=\frac{PM^2\cdot GC^2}{MC^2}.$$

But $PM^2=BM\cdot MC$, since PM is the altitude of a right triangle inscribed in semi-circle

Hence

$$FG^2=\frac{BM\cdot GC^2}{MC}. \tag{5}$$

But using the first two ratios of (4) we have

$$BM:MC=BF:GC.$$

Substituting in (5) we obtain

$$FG^2=BF\cdot GC.$$

Solutions were also offered by: Leon Bankoff, Los Angeles; W. G. Koellner, Hillside, New Jersey; C. W. Trigg, Los Angeles City College; Herta Taussig Freitag, Va.; A. R. Haynes, Tacoma, Wash.; John Lowenthal, Exter, N. H.; W. J. Cherry, North Riverside, Ill.; Julian H. Braun, Washington, D. C.; Lester Moskowitz, Brookyin.

2380. *Proposed by Eugene D. Nichols, Urbana, Ill.*

Solve the system

$$x\left(\frac{y}{z}+\frac{z}{y}\right)=a$$

$$y\left(\frac{x}{z}+\frac{z}{x}\right)=b$$

$$z\left(\frac{x}{y}+\frac{y}{x}\right)=c.$$

Solution by W. J. Cherry, North Riverside, Ill.

The equations may be written:

$$\frac{xy}{z}+\frac{yz}{y}=a \tag{1}$$

$$\frac{xy}{z}+\frac{yz}{x}=b \tag{2}$$

$$\frac{xz}{y}+\frac{yz}{x}=c. \tag{3}$$

Subtract (2) from (1) and add the result to (3); subtract (3) from (1) and add the result to (2); subtract (1) from (3) and add the result to (2). Then divide both members of each equation by 2, getting

$$\frac{xz}{y}=\frac{a-b+c}{2} \tag{4}$$

$$\frac{xy}{z}=\frac{a-c+b}{2} \tag{5}$$

$$\frac{yz}{x}=\frac{c-a+b}{2}. \tag{6}$$

Multiply (4) by (5), getting

$$x^2=\frac{a^2-(c-b)^2}{4};$$

whence

$$x=\frac{\sqrt{a^2-(c-b)^2}}{2}.$$

By similar procedure get

$$y=\frac{\sqrt{b^2-(a-c)^2}}{2}. \qquad z=\frac{\sqrt{c^2-(a-b)^2}}{2}.$$

Solutions were also offered by: Margaret F. Willerding, St. Louis, Mo.; Nathaniel Grossman, Aurora, Ill.; H. M. Feldman, St. Louis, Mo.; C. W. Trigg, Los Angeles City College; A. R. Haynes, Tacoma, Wash.; Richard R. Williams, Jr., Marshall, Texas; William H. Dannacher, Wayne, Pa.; R. L. Moenter, Fremont, Nebr.; James F. Gray, San Antonio; Julian H. Braun, Washington, D. C.; Lester Moskowitz, Brooklyn.

2381. *Proposed by C. W. Trigg, Los Angeles City College.*

The sum of the nth and the $(n+1)$th elements of the fourth row of the Pascal (arithmetic) triangle equals the sum of the squares of the first $n+1$ integers.

Solution by James H. Means, Huston-Tillotson College

By mathematical induction

$$1^2+2^2+3^2+\cdots+n^2+(n+1)^2=\tfrac{1}{6}(n+1)(n+2)(2n+3).$$

The fourth row of Pascal's triangle is

$$1, 4, 10, \cdots, \tfrac{1}{6}n(n+1)(n+2), \tfrac{1}{6}(n+1)(n+2)(n+3), \cdots.$$

Adding the n and $n+2$th terms we get

$$\frac{n}{6}(n+1)(n+2)+\tfrac{1}{6}(n+1)(n+2)(n+3)=\tfrac{1}{6}(n+1)(n+2)(2n+3).$$

Solutions were also offered by: Nathaniel Grossman, Aurora, Ill.; A. R. Haynes, Tacoma, Wash.; R. L. Moenter, Midland College, Fremont, Nebr.; Richard H. Bates, Milford, N. Y.; Julian Braun, Washington, D. C.; James F. Gray, S.M., San Antonio; Lester Moskowitz, Brooklyn.

2382. *Proposed by W. R. Warne, Mt. Pleasant, Ia.*

Solve with skill

$$\frac{3x-25}{3x-1}=\frac{3x+5-6\sqrt{3x}}{3x+2-3\sqrt{3x}}.$$

Solution by Julian Braun, Washington, D. C.

Subtracting 1 from each side of the equation and dividing by -3 we obtain

$$\frac{8}{3x-1}=\frac{\sqrt{3x}-1}{3x-3\sqrt{3x}+2},$$

$$=\frac{1}{\sqrt{3x}-2}.$$

whence

$$3x-8\sqrt{3x}+15=0,$$

$$(\sqrt{3x}-3)(\sqrt{3x}-5)=0,$$

$$\sqrt{3x}=3, 5.$$

Therefore

$$x=3, 8\tfrac{1}{3}.$$

Solutions were also offered by: M. Angela Dolores, Notre Dame, Ind.; Lester Moskowitz, Brooklyn; W. J. Cherry, North Riverside, Ill.; Margaret F. Willerding, St. Louis, Mo;. R. L. Moenter, Fremont, Nebr.; Mercy Heath, Yuma, Arizona,; Nina Ban Nostrand, Robbinsdale, Minn.; Nathaniel Grossman, Aurora, Ill.; Margaret Joseph, Milwaukee, Wis.; Margaret D. Zwicky, Oak Park, Ill.; Roby Fretwell, Keokuk, Iowa; H. M. Feldman, St. Louis, Mo.; Richard H. Bates, Milford, N. Y.; C. W. Trigg, Los Angeles City College; A. R. Haynes, Tocoma, Wash.; William H. Dannacher, Wayne, Pa.; Miss Olivia Franzln, Milwaukee, Wis.; Charles Bibeau, Biloxi, Miss.; J. W. Lindsey, Amarillo, Texas; James F. Gray, San Antonio, Texas.

Correction

In the November, 1953, issue, page 663, Mr. Braun's answer as given was for the original proposal.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each high school contributor will receive a copy of the magazine in which the student's name appears.

For this issue the Honor Roll appears below.

2382. *Larry Jackson, Kipton, Ohio; L. M. Steel and W. M. Clark, Culver, Ind. Military Academy; Dennis Meyer and Harold Kuester, Milwaukee; Joan Brichacek, Trinity H. S., Ill.*

2377. *Patricia Muench, Boulder Creek, Calif.*

2377, 9, 2380, 2. *Geoffrey Kandall, Far Rockaway, N. Y.*

PROBLEMS FOR SOLUTION

2395. *Proposed by Richard H. Bates, Milford, N. Y.*

In right triangle ABC, with C the right angle, if medians are drawn to sides a and b, and an altitude to c, show that these three lines form an interior triangle whose area is given by

$$K=\frac{ab(b^2-a^2)^2}{c(a^2+c^2)(b^2+c^2)}.$$

2396. *Proposed by L. H. Lange, Valparaiso University.*

Show that the slope, m, of a bisector of an angle between two lines satisfies $m^2=1$, if the slopes of the two given lines are reciprocals.

2397. *Proposed by Leon Bankoff, Los Angeles.*

In triangle ABC, $C=90°$, P is a point on AC and Q is a point on CB. If R and S are projections of P and Q respectively on AB, show that

$$PR\cdot QS=AS\cdot BR-RS\cdot AB.$$

(a challenge to high school students)

2398. *Proposed by Roy Wild, University of Idaho.*

Use this as a definition:

$$\arctan x = \int_0^x \frac{dt}{1+t^2}.$$

Show from this that for $0 \leq x < 1$

$$2 \arctan x = \arctan \frac{2x}{1-x^2}.$$

2399. *Proposed by Leon Bankoff, Los Angeles.*

In a circle center C, AB is a diameter, and E is the mid-point of the radius DC perpendicular to AB. AE extended meets arc BD in F. Show by elementary geometry that the area of triangle ECF is equal to $3\,\overline{AC}^2/20$.

2400. *Proposed by C. W. Trigg, Los Angeles City College.*

There are two five digit numbers whose last three digits are unlike and in geometric progression not necessarily in natural order, and whose squares contain the ten digits once each. Find them and show that there are no others.

BOOKS AND PAMPHLETS RECEIVED

GENERAL CHEMISTRY, by Linus Pauling, *Professor of Chemistry, California Institute of Technology*. Cloth. Pages xii+710. 15×23 cm. 1953. W. H. Freeman and Company, San Francisco, Calif. Price $6.00.

ELEMENTS OF PHYSICS, by D. Lee Baker, Raymond B. Brownlee, and Robert W. Fuller. Cloth. Pages ix+677. 15.5×23.5 cm. 1953. Allyn and Bacon, Inc., 2231 South Park Way, Chicago 16, Ill.

SPACE TRAVEL, by Kenneth W. Gatland, and Anthony M. Kunesch. Cloth. Pages 205. 13.5×21.5 cm. 1953. Philosophical Library, 15 East 40th Street, New York 16, N. Y. Price $4.75.

NUCLEAR PHYSICS, by W. Heisenberg, *Director of the Max Planck Institute of Physics, Göttingen*. Paper. Pages ix+225. 12×18.5 cm. 1953. Philosophical Library, 15 East 40th Street, New York 16, N. Y. Price $4.75.

ROGER BACON IN LIFE AND LEGEND, by E. Westacott. Cloth. 140 pages. 12×18.5 cm. 1953. Philosophical Library, 15 East 40th Street, New York 16. N. Y. Price $3.75.

PLANE TRIGONOMETRY by Paul R. Rider, Ph.D., *Professor of Mathematics, Washington University*. Cloth. Pages viii+180. 13×21 cm. 1949. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $3.00.

SEMIMICRO QUALITATIVE ANALYSIS, Revised Edition, by Hervery Bubbard Barber, *Professor Emeritus of Chemistry, University of Minnesota*, and T. Ivan Taylor, *Professor of Chemistry, Columbia University*. Cloth. Pages xi+404. 15×23.5 cm. 1953. Harper and Brothers, 49 East 33rd Street, New York 16, N. Y. Price $4.50.

LABORATORY EXPERIMENTS IN PHYSICS FOR USE WITH ELEMENTS OF PHYSICS, by C. Lee Baker, Raymond B. Brownlee, and Robert W. Fuller. Paper. Pages xii+272. 19×25.5 cm. 1953. Allyn and Bacon, Inc., 2231 South Park Way, Chicago 16, Ill.

TESTS, ELEMENTS OF PHYSICS, by C. Lee Baker, and Raymond B. Brownlee. Paper, 46 pages, 21×28 cm. 1953. Allyn and Bacon, Inc., 2231 South Park Way, Chicago 16, Ill.

BOOK REVIEWS

PHYSICS, PRINCIPLES AND APPLICATIONS, Second Edition, by Henry Margenau, Eugene Higgins, *Professor of Physics and Natural Philosophy, Yale University;* William W. Watson, *Professor of Physics and Chairman of the Department, Yale University;* and C. G. Montgomery, *Late Associate Professor of Physics, Yale University.* Cloth. Pages xii+814. 15×23 cm. 1953. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y. Price $7.50.

The comments of the publishers and authors concerning this text are very pertinent. "This excellent new edition of a successful engineering-physics text covers all the subjects normally covered in an introductory physics course. Through its rigorous development, it is particularly suitable for science majors and engineers who are taking the calculus simultaneously." The authors comment in the preface to second edition: "Since we felt that the book was, on the whole, a little too rigorous, we have omitted some of the most difficult portions, particularly in the subjects of electricity and magnetism."

The authors prepared this text for use in a sophomore physics course at Yale University. It assumes the student has had an introduction to calculus and is taking a "more solid course" concurrently with the physics course.

For these reasons, the reviewer feels this book will be best for a highly selected group of students. Despite this questioned introduction, there are several excellent features in this text.

The amount of material is more than sufficient for a one year course. This permits the instructor to select, organize, and emphasize the materials he feels needed in his own teaching situation. The less important and more difficult sections are in smaller print. The problems relating to these sections are starred. Each of the fifty chapters has many excellent problems. These problems are well selected and excellently illustrated in many cases. The diagrams and illustrations are very helpful for understanding the textual material. This text places emphasis on the MKS units of measurement which are applicable to other phases of engineering. The many new developments of science are adequetely explained and discussed. The final chapter on Nuclear Physics is very complete with charts and illustrations of the latest developments in this field.

E. WAYNE GROSS
University School
Bloomington, Indiana

PLANE AND SPHERICAL TRIGONOMETRY, With Tables, Second Edition, by Donald H. Ballou, *Middlebury College,* and Frederick H. Steen, *Allegheny College.* Cloth, Pages vi+205+84. 23 cm ×15.5 cm. 1953. Ginn and Company, New York. Price $3.50.

This is a very complete text in trigonometry including more work on complex numbers, graphs of functions and spherical trigonometry than is found in most texts of this type. The general approach throughout is to emphasize the understanding of principles and increase facility in their use. The use of vectors is quite extensive and the applications are significant. In the problems much use is made of pictures and drawings. Much meaning is given the trigonometric functions by the use of graphs. The text continually keeps before the student the concept of function.

Angle measure by degrees, radians and mils are all three presented and there are some problems applying to each system of measure. Significant digits are considered in problems and the proper degree of precision is a part of the problem. The text contains a number of oral exercises intended to increase the student's concepts of numbers and their use. Identities are treated with thoroughness but only because of the applications where they simplify procedure. There are numerous problems of the story type which require careful and complete analysis. The book has a good set of tables in the appendix, including all those needed for solving problems of the text. Answers are given to all the problems.

This is not an easy text but it is well written. The future professional who masters the material in this text will find he has a sound basis for his future work in mathematics and science.

PHILIP PEAK
Indiana University

GENERAL CHEMISTRY, Linus Pauling, *Professor of Chemistry, California Institute of Technology.* Cloth. Pages xii+710. 15×23 cm. 1953. W. H. Freeman and Company, San Francisco, California. Price $6.00.

This text carries the substitle "An Introduction to Descriptive Chemistry and Modern Chemical Theory." According to the author, this text, a second edition of a book first published in 1947, is especially designed for students who have had no previous chemistry; however, the approach is enough different from that of most high school texts to make it a suitable college text for students who have had high school chemistry.

Although the sub-title suggests that emphasis would probably be placed on descriptive, chemistry, the reviewer feels that much greater emphasis is placed on the basic principles and important laws of chemistry. In 1906 Alexander Smith wrote his *Introduction to Inorganic Chemistry* which made of general chemistry a science instead of a hodge-podge of facts. This text and its many revisions were so well received that for the past 50 years practically all general college chemistry texts have been patterned after it. Dr. Pauling in his text *General Chemistry* set a new pattern which may well dominate the general chemistry textbooks of the next 50 years. His main innovation is the excellent way in which he has explained the properties of matter in terms of the structure of matter. Throughout the book, we find good use made of diagrams that appear to be three-dimensional, which aid considerably in connecting properties with structure. The language is simple and clear. In the preface to the second edition, the author states: "The Introduction of new general principles through the development of theoretical chemistry has made it possible to leave out some of the material formerly included in the first year course. In particular, a smaller amount of time can now be devoted to learning the facts of descriptive chemistry, because many of these facts have been correlated and systematized by new principles."

The second edition differs from the first in having two additional chapters dealing with atomic structure. There has also been added a well written chapter on the subject of biochemistry.

The publishing company has given the book a good form, good paper, and the print is easily read; the book is well bound and there are 193 well selected illustrations.

At the end of many of the chapters the authors has included an appropriate list of good reference books. The reviewer feels that lists of suitable journal articles are just as important and could well have been included.

If the college chemistry teacher feels that he would like to adopt a new kind of textbook with a different approach to the field of general chemistry, the reviewer recommends that he give serious consideration to GENERAL CHEMISTRY by Linus Pauling. Students who master this text will have an excellent background for further studies in chemistry.

GERALD OSBORN
Western Michigan College
Kalamazoo, Michigan

A SURVEY OF MODERN ALGEBRA, Revised, by Garrett Birkhoff, *Professor of Mathematics, Harvard University*, and Saunders Mac Lane, *Professor of Mathematics, The University of Chicago.* Cloth. Pages xi+472. 14.5×21.5 cm. The Macmillan Company, New York, N. Y., 1953. Price $6.50.

The first edition of this book was published in 1941. The revised edition, as was the first edition, was written as a text for advanced undergraduates or first year graduate students. A wide variety of exercises on each topic have been in-

cluded. The selection of exercises is sufficient to allow the instructor to adapt the text to students of quite varied degrees of mathematical maturity. The chapters are fairly independent of one another which makes the book more adaptable for various types of courses. Many sections have been starred indicating that they may be ommitted without destroying the continuity.

From the viewpoint of both teachers and students the book contains valuable reference material. The text starts in Chapters I and II with the integers and rational numbers, developing the corresponding abstract concepts of integral domains and fields, as well as some of elementary number theory. The next three chapters treat polynomials and both real and complex numbers. Chapter VI introduces the fundamental concept of a group. This is applied in Chapters VII through X, on vector spaces and matrices. Chapters XI and XII deal with classes and cardinal numbers. The last three chapters treat rings and ideals, algebraic number fields, and the Galois theory.

The revised edition rearranges some material, especially that on linear algebra, as well as includes additional exercises and summaries. Also, it has added new topics such as equations of stable type, dual spaces, the projective group, etc.

The book contains an important bibliography and easy reference to topics is provided by an exceptional index. Also, an index of special symbols is given.

CLYDE T. MCCORMICK
Illinois State Normal University
Normal, Illinois

A BRIEF SURVEY OF MODERN ALGEBRA, by Garrett Birkhoff, *Professor of Mathematics, Harvard University*, and Saunders Mac Lane, *Professor of Mathematics, The University of Chicago*. Cloth. Pages viii+276. 14.5×21.5 cm. The Macmillan Company, New York, N. Y., 1953. Price $4.75.

This book is a shorter version of the authors', A Survey of Modern Algebra, Revised Edition, 1953.

The Brief Survey of Modern Algebra consists of chapters I through X of the new revised edition with certain deletions at the end of each chapter. The more important topics ommitted are: Peano postulates, Eisenstein criterion, partial fractions, Dedekind cuts, solution of quartic by radicals, equations of stable type, quotient-groups, abstract equivalence relations, dual spaces, linear algebras, affine and projective spaces, invarient subspaces and matrix reducibility, and canonical forms of matrices.

The brief edition and the revised edition of Modern Algebra have the same chapter and section numbering, while the corresponding page numbers in the complete edition are given in the inner margin of the brief edition. This provides for using both the brief edition and the complete edition in the same course without confusion in the course assignments.

The book contains a short bibliography, an index of special symbols, and a general index which is quite complete.

CLYDE T. MCCORMICK

TRIGONOMETRY, by John F. Randolph, Ph.D., *Professor and Chairman of the Department of Mathematics, University of Rochester*. Cloth. Pages x+220. 13.5×21 cm. 1953. The Macmillan Company, 60 Fifth Ave., New York 11, N. Y. Price $3.00.

One's first thought on seeing this book is that this is another very brief outline of trigonometry, especially when one finds that only 125 pages are devoted to trigonometry. (The balance of the text consists of three appendices, one on elementary algebra; one on some elementary analytic geometry, which is used in the development of the subject matter; and one on logarithms.) However, more careful inspection of the book shows a surprising amount of material has been covered. The book is frankly planned for college students, and should provide not only a sound mathematical course for the student who goes no farther, but a good background for further mathematics courses.

The general angle is introduced first; an unusual proof of the addition and subtraction formulas is given which makes use of rotation on the unit circle; the proper statement is made that certain functions of special angles are undefined, rather than the confusing statement that these functions equal infinity; in graphing the importance of the proper scale on both axes (using radian measure rather than an arbitrary scale) is stressed; in the material on logarithms the characteristic comes from a definition rather than a mechanical rule (possibly harder to teach, but it should lead to a better understanding). An unusual form of expression is "function at 30°" rather athn "function of 30°."

At a few points some instructors may be displeased. Fundamental identities seem to be proved in Chapter II, and again in Chapter V, without any reference to the previous discussion. The number of problems is inadequate in some places to provide for alternate assignments in successive semesters. (Answers are provided to approximately half the exercises.) Some may feel that insufficient attention is give to certain topics, for example, proving identities. Solutions of triangles are made by using four, rather than five place tables. The index is not always complete—as a single example, it does not give "quadrantal angles."

Definitely one has here a book relatively small in size, but also definitely not small in content—certainly worth considering as a college text.

CECIL B. READ

MEETING OF ARAB SCIENTISTS PLANS PERMANENT ASSOCIATION

The first Arab Science Congress, meeting at Alexandria, Egypt, in September took steps to organize Arab Scientists and the scientific institutions of the Arab states into a permanent Arab Scientific Union. A preparatory committee will prepare the plans and secure the co-operation of the governments and scientists during the year ahead and expects to call a second Arab Science Congress in 1954 or 1955 for the organization of an Arab Scientific Union.

The publication of a general science journal in Arabic and the encouragement of the study of the history of Arab science are included in the objectives. The public lectures at the Congress included a review of the great names of Arab science, such as Jabir-ibn-Haiyan, known in the western world as Geber, and Ibn Sina, known as Avicenna. Other lectures reviewed the historic contributions of Arabic scientists to mathematics, physics and the nautical sciences.

The Congress was called by the Cultural Administration of the Arab League and was opened by President Mohammed Neguib of Egypt. A total of 321 scientists attended from eight Arab countries: Egypt, Irak, Jordan, Koweit, Lebanon, Syria, Saudi Arabia and Yemen. There were 65 scientific papers and active discussions of the problems of the Arab countries with respect to scientific terminology, the translation into Arabic, and publication of scientific papers and books, the training of science teachers and the relation of science to the national economies.

The heads of the major delegations attending the Congress were: Prof. Mustafa Nazif, Vice-Rector of the University of Ibrahim (Egypt); Dr. Sheeth Nu'mann, Director of the Research Council (Irak); Mr. Mohamed Adib el Amry (Jordan); Melle Solwa Nassar (American University, Lebanon) and Prof. Toufik Mounadjed, Dean of the Faculty of Science of Damascus (Syria).

A feature of the Congress was an exhibit of manuscripts and scientific publications concerning Egypt, installed at the Faculty of Commerce of the University of Alexandria. President Neguib also formally opened the Unesco science exhibition on "New Materials" at the Polytechnic Faculty. This exposition, containing more than 3000 items, manufactured from modern plastics and from the new metals and special alloys, was on exhibit during the entire Congress and has now been moved to Cairo where it will be on public view for about a month. The exhibit had previously been shown at Belgrade, Ljubljana and Zagreb in Yugoslavia and at Istanbul in Turkey.

A PAMPHLET ON HOMEMAKING

Building a close relationship between school experiences and home experiences has been a characteristic part of homemaking instruction ever since Federal funds were first made available for the development of vocational education programs in homemaking.

Preparation for home and family living is more and more being considered one of the important goals of education in the modern school. Homemaking education programs in the secondary schools have a unique contribution to make to this preparation, for home economics is the only subject area which is centered on the home activities and relationships which enable the pupil to assume the responsibilities of homemaking.

This bulletin was prepared to show teachers some ways that learning experiences carried on at school, in the home, and in the community can be integrated into a *total* program focused on over-all homemaking education goals.

HOME, SCHOOL, AND COMMUNITY EXPERIENCES IN THE HOMEMAKING PROGRAM. By Druzilla Kent, Margaret Alexander, and Mary Laxson. Office of Education Vocational Division Bulletin No. 252, Home Economics Education Series No. 29. 69 pages. 1953. For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. 25 cents.

HANDBOOK OF EDUCATIONAL INFORMATION

Over the years, the language of education has grown, and items of educational information have taken on different meanings in different States. Recognizing the importance of comparability of data and common understanding of basic items, the National Council of Chief State School Officers requested the Office of Education to conduct a cooperative project with State and Territorial departments of education to achieve these objectives. In response, Handbook I is the first of four publications planned in the State educational records and report series.

Handbook I is designed to serve the same purpose for certain basic items of educational information as the dictionary serves for words in the English language. Here for the first time is listed the common core of items of educational information that every State department of education should have available annually; the items are defined, and a glossary of individual terms used in the definitions is included.

Other handbooks in the State educational records and reports series will deal with financial accounting, personnel accounting, and property accounting.

THE COMMON CORE OF STATE EDUCATIONAL INFORMATION. Compiled by Paul L. Reason, Emery M. Foster, and Robert F. Will. Office of Education Bulletin 1953, No. 8, State Educational Records and Reports Series: Handbook I. 116 pages. For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. 35 cents.

Electric hair dryer blows cool or warm air at the flick of a switch. Although the portable device is designed for milady, the manufacturer whispers that husbands can use it in their photographic darkrooms. It makes a fine dryer for negatives and reel-type developing tanks.

Sandbag for cars is easily carried in the trunk and holds enough sand to provide grit when traction is needed on slippery, snow-covered roads. Made of a mildew-proof fabric, the bag has a tapered design which permits the user to control the flow of sand easily.

Carbon drawing ink has been developed that can be used on glass and other water-repellent surfaces without damage due to freezing and thawing. The ink itself can be rendered water resistant by a brief cure at 180 degrees Fahrenheit.